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Forest Insect and Disease Conditions in the United States 1976

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FOREWORD

This publication is the 27th annual Forest Insect and Disease Conditions Report. It is compiled by the Forest Insect and Disease Management Staff, State and Private Forestry, Washington Office. The objective of this report is to provide the reader with a brief description of the incidence, distribution, and trends of insect and disease outbreaks on lands of all ownerships on a year-to-year basis.

The information in this report is provided by professional forest entomologists and pathologists throughout the country. Part of the information provided comes to the entomologist and pathologist from the interested public, as well as from private, State, and Federal professional foresters and land managers. Cooperating Federal and State forest insect and disease specialists conduct continuing surveillance and detection activities to locate outbreaks and/or to provide data for evaluating the status and biological potential of the outbreak.

Surveillance methods and data collection are continually being updated to provide the most accurate information and technical assistance possible to the land manager for use in making important forest resource management decisions. Information on management to help prevent or minimize forest losses from insect and disease attack, such as maintaining a vigorous growing stock, planting insect and disease resistant varieties, and planting only those species of trees compatible to a particular growing site, is also provided.

Additional information on the insect or disease situations mentioned in this publication can be obtained by contacting the Forest Service regional offices directly.

For their assistance in compiling this report, we wish to thank entomologist Iral Ragenovich, Southeastern Area, State and Private Forestry, Asheville, N.C., Field Office; and to pathologist Phylis Dugar, Southeastern Area, State and Private Forestry, Pineville, La., Field Office.

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This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife–if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

Issued September 1978

THE NATIO
PACIFIC NORTHWEST REGION
PACIFIC NORTHWEST
PORTLAND
OLYMPIC
MT BAKER
OKANOGAN
COLVILLE
KANIKSU
KOOTENAI
WENATCHEE
SNOQUALMIE
GIFFORD PINCHOT
WASH.
MT HOOD
SIUSLAW
WILLAMETTE
UMPQUA
SISKIYOU
ROGUE RIVER
CROOKED RIVER
UMATILLA
WALLOWA
WHIT MAN
OCHOCO
DESCHUTES
MALHEUR
FREMONT
OREG.
KLAMATH
MODOC
SIX RIVERS
SHASTA TRINITY
LASSEN
MENDOCINO
PLUMAS
TAHOE
PACIFIC SOUTHWEST
ELDORADO
STANISLAUS
CALAVERAS BIG TREE
SAN FRANCISCO
SIERRA
CALIFORNIA
LOS PADRES
REGION
SEQUOIA
INYO
TOIYABE
LOS PADRES
CALIF.
ANGELES
SAN BERNARDINO
CLEVELAND
COEUR D'ALENE
FLATHEAD
NORTHERN REGION
LEWIS AND CLARK
ST JOE
LOLO
MISSOULA
CLEARWATER
HELENA
LEWIS AND CLARK
MONT.
DEER LODGE
NEZPERCE
BITTER ROOT
PAYETTE
SALMON
BEAVERHEAD
GALLATIN
CUSTER
CHALLIS
BOISE
SAWTOOTH
IDAHO
TARGHEE
TETON
SHOSHONE
BIGHORN
CUSTER
LITTLE MISSOURI
N. DAK.
CEDAR RIVER
GRAND RIVER
S. DAK.
BLACK HILLS
THUNDER BASIN
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WYO.
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NEBRASKA
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NEBRASK
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HUMBOLDT
CURLEW
CACHE
OGDEN
BRIDGER
NEV.
INTERMOUNTAIN
WASATCH
ASHLEY
UINTA
MEDICINE BOW
ROUTT
PAWNEE
ROCKY MOUNTAIN
ROOSEVELT
ARAPAHO
DENVER
ROCKY MOUN
REGION
WHITE RIVER
GRAND MESA
PIKE
UNCOMPAHGRE
GUNNISON
SAN ISABEL
COLO.
FISHLAKE
MANTI LA SAL
UTAH
DIXIE
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COMANCHE
CIMARRON
KAIBAB
SOUTHWESTERN REGION
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RITA BLANCA
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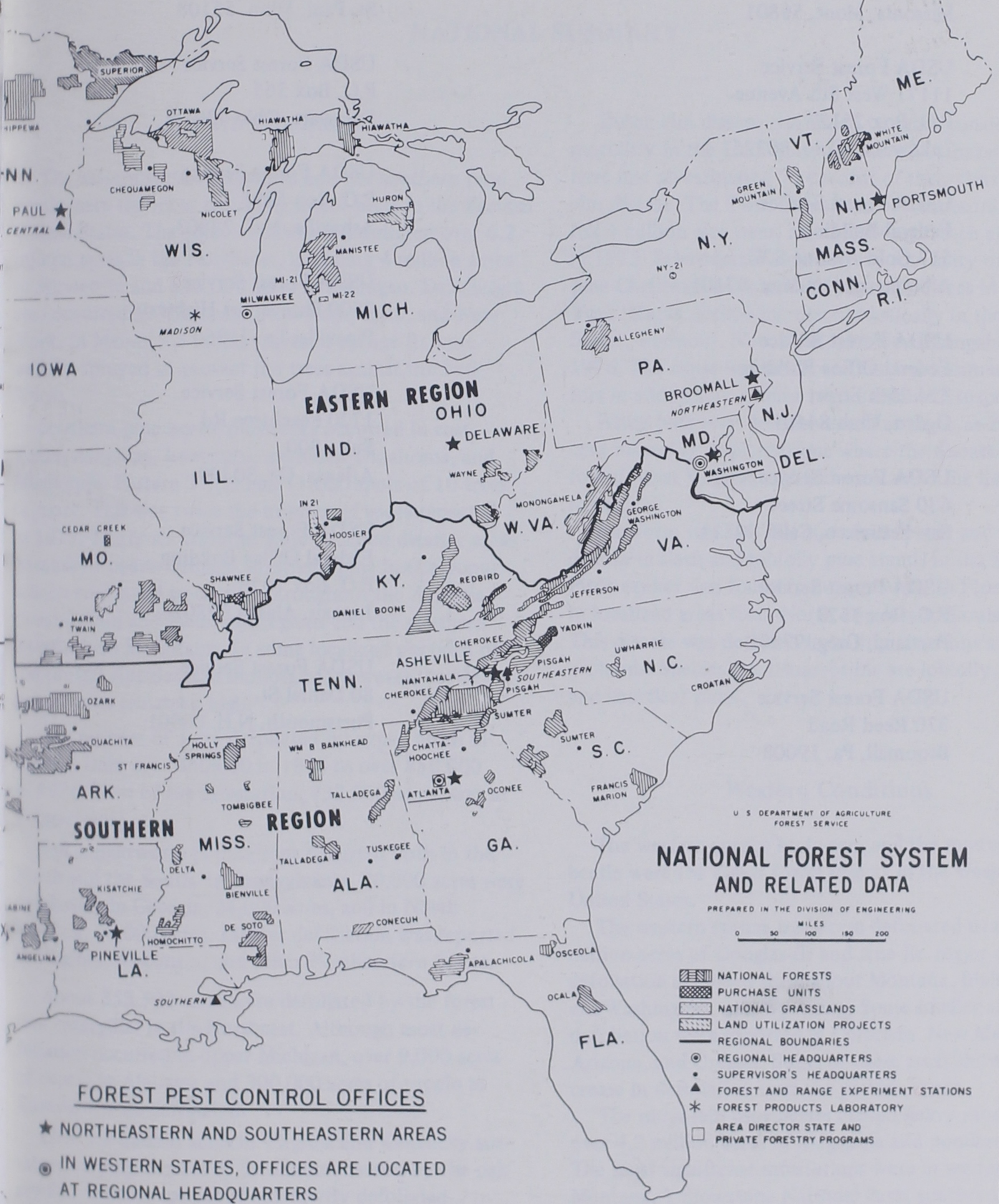

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FOREST PEST CONTROL OFFICES

★ NORTHEASTERN AND SOUTHEASTERN AREAS

◉ IN WESTERN STATES, OFFICES ARE LOCATED AT REGIONAL HEADQUARTERS

Forest Pest Control offices are located at the following addresses; see map on pages iv and v.

USDA Forest Service
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P.O. Box 25127
Lakewood, Colo. 80225

USDA Forest Service
Federal Building
517 Gold Avenue S.W.
Albuquerque, N.Mex. 87101

USDA Forest Service
Federal Office Building
324 25th Street
Ogden, Utah 84401

USDA Forest Service
630 Sansome Street
San Francisco, Calif. 94111

USDA Forest Service
P.O. Box 3623
Portland, Oreg. 97208

USDA Forest Service
370 Reed Road
Broomall, Pa. 19008

USDA Forest Service
Folwell Avenue
St. Paul, Minn. 55108

USDA Forest Service
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Delaware, Ohio 43015

USDA Forest Service
P.O. Box 5895
Asheville, N.C. 28803

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USDA Forest Service
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P.O. Box 1628
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USDA Forest Service
80 Daniel St.
Portsmouth, N.H. 03801

FOREST INSECT AND DISEASE CONDITIONS IN THE UNITED STATES, 1976

NATIONAL SUMMARY

Eastern Conditions

The eastern spruce budworm and the southern pine beetle were the most damaging insect pests in the Eastern United States. The spruce budworm defoliated over 6.2 million acres in the Northeast, including 4 million acres in Minnesota and 815,000 acres in Michigan. Defoliation also occurred in Wisconsin, New Hampshire, and New York. In Maine, 3.5 million acres of spruce-fir were aerially sprayed to protect the trees against the budworm.

Southern pine beetle outbreaks occurred in east Texas, Arkansas, Louisiana, southeast Oklahoma, and Mississippi. Eastern Texas had 11,000 spots of 10 trees or more. This was twice the number of spots reported in 1975. Thirty-six counties were declared disaster areas because of beetle damage. Southern pine beetle populations continued to decline throughout the Atlantic Coastal Plain and Piedmont regions and the southern Appalachian Mountains. In some localized portions of the central Appalachian Mountains, however, beetle populations remained high.

The number of acres defoliated by gypsy moth increased from over 460,000 in 1975 to over 850,000 in 1976. Most of the infestation, 732,000 acres, was in Pennsylvania.

Fall cankerworm populations occurred both in the North and the South. In Pennsylvania, 70,000 acres were defoliated, in Georgia, 24,000 acres, and in North Carolina, 26,000 acres. Lighter defoliation was reported in Virginia, Wisconsin, and other Northeastern States.

About 352,500 acres were defoliated by the forest tent caterpillar in the Northeast. Although most defoliation occurred in upper Michigan, over 9,000 acres of tupelo in Alabama and 300,000 acres of tupelo in Louisiana were defoliated.

Over 3.3 million acres in Virginia and Kentucky sustained varying degrees of defoliation caused by the oak sawfly. Another species of oak sawfly defoliated 100,000 acres in West Virginia. In Upper Michigan, 150,000 acres were affected by the arborvitae leaf miner, and 120;000 acres were defoliated by the oak leaftier in Virginia and Massachusetts.

Dutch elm disease continued to cause considerable mortality in the Lake States. Twelve Northeastern States have lost an estimated 75 percent of their elms to Dutch elm disease. The Twin Cities area of Minnesota, which has 4 million elm trees, lost 25,000 to Dutch elm disease in 1975. Scleroderris caused heavy mortality on Scots pine Christmas trees and red pine of all sizes in New York. Maple decline increased drastically in the Lake States, Vermont, New York, and New Hampshire in 1976. The cause was unknown, but environmental factors in addition to disease organisms were suspected.

White pine root decline caused as much as 20 percent mortality in plantations where the disease was found. West Virginia and Ohio sustained the heaviest losses.

Fusiform rust was the most widespread and serious disease in slash and loblolly pine stands in the South. Pitch canker was found in every county in Florida and in localized areas from North Carolina to Louisiana. This disease was detected in both plantations and seed orchards. Species most susceptible are loblolly, slash, and shortleaf pines.

Western Conditions

The western spruce budworm and the mountain pine beetle were the major forest insects in the Western United States.

The western spruce budworm defoliated nearly 5.8 million acres of Douglas-fir and true fir. Major areas of defoliation occurred throughout Montana, Idaho, eastern Washington, and Wyoming. Some smaller areas of defoliation were reported in Colorado, New Mexico, Arizona, and Oregon. Some of these areas showed an increase in defoliation over the previous year.

The mountain pine beetle caused heavy mortality in over 4.2 million acres of lodgepole and ponderosa pine. The most significant infestations were in western Montana, Yellowstone National Park, southern Idaho, eastern Oregon, and the Black Hills of South Dakota. Infestations were increasing in Wyoming and Utah, and scattered infestations were reported in California, northern Arizona, and New Mexico.

Douglas-fir tussock moth populations collapsed in the Northwest. The only reports of the tussock moth were of light to moderate areas of defoliation in parts of Utah, Arizona, and New Mexico.

A small established infestation of gypsy moth was found south of San Jose, Calif. This was the first report of gypsy moth infestation in the Western United States.

Other insect pests included the western pine beetle which increased in California in the late fall following drought conditions. Heavy infestations were also reported in central Oregon. Douglas-fir beetle infestations increased significantly in eastern Oregon and Washington. Activity also increased in southern Idaho and Wyoming. Throughout the rest of the Western United States, the Douglas-fir beetle was at endemic levels. Larch casebearer populations declined in the Northern Region, but continued to defoliate larch in eastern Washington.

In Alaska, the spear-marked black moth infestation collapsed. A new species of larch defoliator was found on 590,000 acres of Tamarack in the Tenana River Valley. The eastern larch beetle caused scattered tamarack mortality on over 350,000 acres.

Dwarf mistletoes continued to be the most destructive pathogens affecting conifer stands in western regions, with damage resulting in growth loss and tree mortality. On ponderosa pine alone, southwestern dwarf mistletoe is responsible for an estimated net volume loss of 150 million board feet annually.

Dutch elm disease continued to spread west and poses a serious threat throughout the area. Sixteen States west of the Mississippi River have now reported the disease. It was detected in California for the first time in 1976.

Root rots caused by *Armillariella*, *Verticicladiella*, and *Fomitopsis* were responsible for significant amounts of mortality in several managed conifer stands throughout this area. Armillariella root rot centers of 20-30 acres were detected in Montana. Black stain root disease caused by *Verticicladiella wagnerii* caused mortality in Douglas-fir throughout western Oregon and Washington, and in pinyon pine in northwestern New Mexico. Annosus root rot infection centers caused by *Fomitopsis annosa* increased throughout Idaho's National Forests in conifer stands.

Needle diseases were among the most obvious western disease problems in 1976. *Lophodermella concolor* caused a needle blight of lodgepole pine seedlings and saplings over several thousand acres in eastern Oregon, western Montana, and northern Idaho. Damage resulted in growth loss, but no mortality. *Rhadocline pseudotsugae* was a common needle blight pathogen in western Oregon and Washington Douglas-fir stands, especially on offsite trees. *Elytroderma deformans* continued to cause a needle blight in ponderosa pine in eastern Oregon and Washington and western Montana.

Damping-off, caused by *Fusarium* spp., *Phytophthora*, *Pythium* complex, *Rhizoctonia*, or *Botrytis cinerea*, killed seedlings in many western nurseries. The Placerville Nursery in California lost 49 percent of its sugar pine seedlings to a *Rhizoctonia/Fusarium* complex.

Forest resources were damaged by air pollutants in some areas. Hydrogen fluoride from an aluminum plant in northwestern Montana injured most of the vegetation within 5 miles of the smelter. Injury and damage to trees from a large copper smelter at Anaconda, Mont., continued and acidification of soils was evident over a large area. Nearly 1 million acres of forested lands in Montana and Idaho sustained varying amounts of pollutant-caused damage. Ozone injury to ponderosa and Jeffrey pines was common in parts of the southern Sierra Nevada downwind from major urban centers.

NORTHERN REGION (R-1)[1]

by

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Spruce budworm continued to be a major pest in the Northern Region. Over 3 million acres of defoliation were visible from the air in 1976. Egg mass surveys completed in the fall indicated that the infestation would continue at nearly the same level with some increase in 1977 on eastern Montana forests. Pilot control projects against the spruce budworm on the Helena National Forest in June involved Dylox 1.5 Oil[R] and Orthene Forest Spray[R]. Larch casebearer populations decreased. The only reports of extensive defoliation occurred near Bonners Ferry, Idaho. Douglas-fir tussock moth populations collasped.

Mountain pine beetle losses increased on the Gallatin, Kootenai, and Lolo National Forests and Glacier National Park. Portions of Yellowstone National Park exhibited a decrease where the food supply was dwindling. Pine engraver beetle activity decreased in Montana and Idaho. Fir engraver beetle also decreased; however, 11,000 acres were infested in Idaho. Douglas-fir beetle populations were endemic with only a few group killings in mature unlogged stands.

Heavy losses of container-grown grand fir seedlings were attributed to a species of *Fusarium*. A species of *Botrytis* killed nearly 1,300 container-grown ponderosa pine. Frost heaving resulted in considerable damage to 1-0 Douglas-fir seedlings at the Regional nursery. *Lophodermella concolor* defoliated lodgepole pine in western Montana and northern Idaho. Elytroderma needle cast continued to reinfect ponderosa pine in western Montana. Root disease centers, 20-30 acres in size, were detected on the Lewis and Clark National Forest in eastern Montana with *Armillariella mellea* identified as the causal agent. Large armillariella centers were also detected in western Montana, and management alternatives for these areas are now being explored. An expanded survey of root disease centers caused by *Poria weirii* in northern Idaho and western Montana was in progress. Stem decays and their relationship to hazard trees in Yellowstone Park were being evaluated.

Air pollutants continued to damage forest resources. Two new 350-megawatt, coal-fired electric power plants went online in 1976 in eastern Montana, and SO_2 and NO_X emissions threaten nearby pure stands of ponderosa pine. Hydrogen fluoride from an aluminum plant in northwestern Montana caused widespread injury to most vegetation within 5 miles of the smelter. Injury and damage to trees caused by emissions from a large copper smelter at Anaconda, Mont. continued, and acidification of soils was evident over a large area. Nearly 1 million acres of forested lands of all ownerships in Region 1 sustained varying amounts of pollutant-caused damage.

Status of Insects

Western spruce budworm, *Choristoneura occidentalis* Free. Visible defoliation extended over 3,267,000 acres in Montana and Idaho and in portions of Yellowstone National Park in Wyoming—475,000 acres less than reported in 1975. Total defoliated acreages decreased 175,800 acres in Idaho and 301,700 acres in Montana, and increased 2,600 acres in Wyoming. There was no serious mortality due to the budworm, with less than 1 percent of the volume lost. However, there was about a 15- to 20-percent growth loss in Douglas-fir and a 30-percent growth loss in grand fir. Defoliation was conspicuous and quite severe in the Gallatin Canyon. An environmental impact statement dealing with the alternatives of spruce budworm management was to be prepared.

Pilot control tests for Dylox 1.5 oil[R] and Orthene Forest Spray[R] were conducted on 6,500 acres of the Helena National Forest in June and July. The Dylox formulation effectively controlled 59 percent of the population and the Orthene formulation controlled 86 percent. These values reflect corrections for natural mortality.

Egg mass surveys in the fall indicated 1977 defoliation would range from 41 to 55 percent on the Beaverhead, Bitterroot, Deerlodge, Helena, Gallatin, Lewis and Clark, and Lolo National Forests and surrounding private lands. Moderate defoliation (26 to 40 percent) was expected on a portion of the St. Joe and Kootenai National Forests, and light defoliation (1 to 25 percent) on the Nezperce, Clearwater, and Flathead National Forests. Heavy defoliation was predicted for portions of the Flathead Indian Reservation.

Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.) The Douglas-fir tussock moth infestation collapsed and very little defoliation occurred in 1976. Montana State entomologists helped conduct surveys for newly hatched larvae in the spring in areas where large numbers of male adults were pheromone-trapped

[1] Includes forests in Montana, northern Idaho, North Dakota, northwestern South Dakota, and National Park Service land in northwestern Wyoming.

the previous fall. The purpose of the study was to measure correlation between pheromone trappings and numbers of larvae.

Applications of Orthene Forest Spray[R], Sevin sprayable[R], Dimilin 25W[R], and Pyrocide Growers Spray[R] were tested as ground sprays on individual trees by the State of Montana. All materials provided excellent control.

Larch casebearer, *Coleophora laricella* (Hbn.). Populations of larch casebearer declined in 1976. The only extensive areas of defoliation occurred near Bonners Ferry, Idaho. Stands of green larch were visible for the first time in several years. Parasite releases were continued and *Chrysocharis laricinellae* (Ratz.) was recovered for the first time near Evaro, Mont., where it was released 3 years previous.

Mountain pine beetle, *Dendroctonus ponderosae* Hopk. There were approximately 1,043,000 acres of mountain pine beetle-infested timber in Region 1; 898,000 acres in lodgepole pine, and 143,300 acres in ponderosa pine. Most severe infestations occurred in Jack Creek drainage, Beaverhead National Forest; Gallatin Canyon, and Yellowstone Flats, Gallatin National Forest; Thompson River, Lolo National Forest; and Yaak River drainage, Kootenai National Forest. Infestations increased to include 104,000 acres on the west side of Glacier National Park.

About 3,700 acres of lodgepole pine were infested in the North Fork drainage, Flathead National Forest, adjacent to Glacier National Park. In Yellowstone National Park, Wyo., 614,000 acres were infested. The infestation declined in the southwestern portion of the park where outbreak conditions have persisted for about 9 years. This was attributed mainly to the fact that the mountain pine beetle had already killed most of the large diameter lodgepole pine in that area. New outbreaks developed near Dennis Mountain, Salmon River Breaks Primitive Area, Bitterroot National Forest, Idaho, and an infestation continued in Lincoln Gulch, Helena National Forest, Mont.

Second growth ponderosa pine stands were infested with mountain pine beetle in the Clark Fork River drainage near Missoula, Mont., and on State and private lands in the Blackfoot River drainage from Diamond Mountain east to Clearwater-Blackfoot River Junction. Light infestations in the 1 to 20-tree groups occurred in the Garnet Mountain Range, from Bonner east to Gold Creek. Mortality increased on Federal, State, and private lands in the Belt Mountains, Lewis and Clark National Forest, southeast of Great Falls, Mont. Infestations continued for a third year on the northwest side of Shook Mountain and small 10-tree group kills were detected up the West Fork Bitterroot River drainage, Bitterroot National Forest, Mont. Infestations continued in mixed lodgepole-ponderosa pine stands on State, private, and Federal lands near St. Regis, Mont.

Other insects. The pine engraver, *Ips pini* (Say), was at endemic levels. This was attributed to favorable climactic conditions and good forest management. Throughout most of Region 1, there was an increase in subalpine fir mortality caused by the western balsam bark beetle, *Dryocoetes confusus* Sw. Approximately 7,300 acres were infested. New outbreaks developed on the Beaverhead, Bitterroot, Custer, Deerlodge, Gallatin, and Helena National Forests in Montana. Infestations dropped throughout the Idaho Panhandle, Clearwater, and Nezperce National Forests in Idaho. About 11,000 acres of grand fir on the Clearwater, Nezperce, and Idaho Panhandle National Forests contained infestations of fir engraver beetle, *Scolytus ventralis* LeC. This was a decrease from the previous year. New outbreaks developed on the Stillwater and Swan State Forests in Montana. The Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk., was endemic with some spot mortality in overmature stands.

The larch looper, *Semiothisa sexmaculata* (Pack.), defoliated about 2,000 acres of larch near Thompson Falls, Mont. Historically, larch looper outbreaks last about 2 years and are not considered a serious problem in Region 1. The satin moth, *Stilpnotia salicis* (L.), defoliated about 2,000 acres of cottonwood in the Coeur d'Alene River area and along the St. Joe River drainage. A localized infestation of Douglas-fir needle midge, *Contarinia pseudotsuagae* Cond., was reported along the Blackfoot River on the Seeley Lake District of the Lolo National Forest. A heavy infestation of the pine needle scale, *Phenacaspis pinifoliae* (Fitch), was reported within the city limits of Seeley Lake, Mont. The infestation, evidently, had been established for several years.

Status of Diseases

Nursery diseases. Container grown seedling mortality of grand fir and ponderosa pine was caused by *Fusarium* sp. and *Botrytis* sp., respectively. Minor damage on Douglas-fir nursery bed seedlings was attributed to frost heaving. An unidentified agent causing defoliation and cankers on stems around nodes was noted on western larch nursery stock.

Needle diseases. Pine needle cast fungus, *Lophodermella concolor* (Dearn.) Darker, caused significant defoliation of lodgepole pine in the lower Clark Fork River drainage in Montana for the second successive

year. In addition, severe infection was observed as far south as Lewiston, Idaho, and eastward into western Montana.

Elytroderma deformans (Weir) Darker, causing "Ely witches brooms" continued to reinfect ponderosa and lodgepole pine in western Montana.

Douglas-fir needle cast, caused by *Rhabdocline pseudotsugae* Syd. and a needle rust fungus, *Puccinia-astrum goeppertainum* (Kuehn) Kleb., were infrequently observed in western Montana and northern Idaho on Douglas-fir and true firs, respectively.

Root diseases. Root disease centers up to 20 to 30 acres in size were identified on the Lewis and Clark National Forest. Shoestring root rot fungus *Armillaria mellea* (Vahl ex Fr.) Kumm, was isolated from dead and dying conifers and is considered to be the causal agent. During a limited survey of the Logging Creek and upper Smith River area on the Lewis and Clark National Forest, some 300 to 400 acres were found to be involved (fig. 1).

Figure 1.–*Armillaria* root disease centers in Logging Creek drainage, Lewis and Clark National Forest, Mont.

Root disease centers caused by *A. mellea* were identified with increasing frequency in western Montana. Various sized infection centers had been identified along the west side of the Mission Range on BIA forests; in the Lincoln-Ovando area on Champion International lands; along the southwest slopes of the Swan Range on the Seeley Lake Ranger District, Lolo National Forest; and in the Deborgia area, on the Superior Ranger District, Lolo National Forest. Major host species affected were Douglas-fir, grand fir, subalpine fir, and Englemann spruce.

A survey of root disease centers involving laminated root rot, *Phellinus weirii* (Murr.) Gilb., in northern Idaho and western Montana was conducted. Data were collected to supplement that obtained during the original root disease survey on the Coeur d'Alene National Forest in which 5.1 percent of the commercial forest acreage was estimated lost to root diseases.

An evaluation to determine quantity of airborn inoculum (spores) of annosus root rot, *Fomitopsis annosa* (Fr.) Karst., was begun. Inoculum was found during most months in the three areas sampled.

Stem decay. A survey of major campgrounds and picnic areas in Yellowstone National Park was made to evaluate the hazard tree situation. Potential hazards were standing and leaning dead trees, and standing green trees with butt rot extending into the roots. Significant numbers of potential hazard trees were present in all high-use areas with old-growth lodgepole pine, Englemann spruce, or subalpine fir.

White pine blister rust, *Cronartium ribicola* Fisch and Waldh. White pine blister rust continued to infect and kill all age classes of western white pine in western Montana and northern Idaho.

Dwarf mistletoe, *Arceuthobium* spp. Silvicultural control of dwarf mistletoe was accomplished on 2,144 acres on the Beaverhead National Forest, Mont. in conjunction with normal timber management activities.

LPMREV, a simulated yield computer program, was ready for use as a decisionmaking tool in the management of dwarf mistletoe-infested lodgepole pine stands.

Dutch elm disease, *Ceratocystis ulmi* (Buism.) C. Mor. Dutch elm disease was confirmed on ten American elms in Missoula, Mont. Four of these were on the University of Montana campus with the remainder scattered throughout the city.

A survey of urban tree conditions in Great Falls, Mont. showed that most of the trees were in relatively poor condition as a result of the drier-than-normal summer of 1973; nearly all American elm exhibited top dieback. These dead tops would be excellent breeding spots for the smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.), an insect vector of Dutch elm disease. Neither the beetle nor the fungus had yet been found in Great Falls.

Air pollutants. Two 350-megawatt coal-fired electric generating plants went on-line in eastern Montana in 1976. It was estimated that annually 58,000 tons of sulfur dioxide (SO_2), 56,000 tons of nitrogen oxides (NO_X), 19 tons of fluoride (F), and 5,000 tons of particulate would be discharged from these two facilities and two 700-megawatt plants planned for the near future. It is probable that these emissions could cause extensive injury to pure stands of ponderosa pine on State, private, and National Forest lands downwind from the steam plants. For this reason, an indepth evaluation to characterize the ponderosa pine system

prior to operation of the plants was initiated in 1975. Estimates of needle retention, needle pathology, needle length, fascicular cross-sectional area, moisture percentage, and total sulfur, fluoride, and chlorophyll content were made on needles collected from 16 permanent plots (fig. 2). Also, current airborne concentrations of SO_2 and F were measured. It was anticipated that future pollutant effects, if any, would be readily discernible by repeating the evaluation at future dates.

Hydrogen fluoride from an aluminum plant at Columbia Falls, Mont. continued to cause widespread and severe injury to Douglas-fir, lodgepole pine, ponderosa pine, western larch, and many associated browse and forage species. Injury was detected on nearly 20,000 acres of State, private, and Federal lands.

Continuing air pollution injury and damage to forest trees from primary metal smelters, aluminum plants, and pulp mills was evident on nearly 1 million acres of forested lands of all ownerships in the Northern Region, resulting in significant impact on timber growth, recreational, and wildlife resources.

Figure 2.–Biological lab technician making routine measurements of total chlorophyll in ponderosa pine needles collected near the Colstrip, Mont., electric generating complex.

ROCKY MOUNTAIN REGION (R-2)[2]

by

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Conditions in Brief

Mortality in ponderosa pine caused by the mountain pine beetle continued on the Black Hills of South Dakota and Wyoming and on the Front Range of Colorado. In both areas the insect populations were expected to remain high. Mountain pine beetle populations in ponderosa pine along the eastern slope of the Bighorn Mountains in Wyoming increased. In the lodgepole pine type, on the Medicine Bow National Forest and in Middle Park in Colorado, mountain pine beetle populations declined. In the vicinity of Atlantic City, Wyo., and on the southern Shoshone National Forest, the insect population was expected to remain at a high level.

Defoliation caused by the western spruce budworm was more widespread in Colorado and was reported in Wyoming for the first time since 1962. A large sawfly infestation occurred in ponderosa pine on the Rosebud Indian Reservation in South Dakota. Several insects continued to damage plantations and shelterbelts in the Plains States. Shade trees in urban areas were lightly to moderately damaged by several insects.

A study was conducted to measure the impact of comandra rust on potential yield of pole and smaller size lodgepole pine. A relatively low level of mortality and damage was found, and tree infections less than 10 years old were infrequent. A preliminary survey of root diseases in managed conifer stands indicated that shoestring root rot, which caused poor survival in several areas, was the most serious problem. This rot was found in Rocky Mountain juniper, which was a new host record in the United States. Diplodia tip blight was detected in all counties surveyed in the eastern third of Nebraska. Dutch elm disease was detected in two new counties of South Dakota. Oak wilt was detected in two additional counties of Kansas. A severe spring frost caused widespread foliage damage to aspen and conifers in most mountainous locations. Seedling losses at Mt. Sopris Tree Nursery were primarily caused by damping-off fungi and bird predation. Studies were continued on on mycorrhizal inoculations of containerized ponderosa pine seedlings. Tumors of unknown cause infected 300 to 400 acres of overmature lodgepole pine in Wyoming.

Status of Insects

Mountain pine beetle, *Dendroctonus ponderosae* Hopk. Salvage logging of beetle-infested trees and an increase in timber sales to improve stand conditions were underway on the Black Hills National Forest where there were an estimated 500,000 infested acres. These operations would make stands less susceptible to attack by mountain pine beetle and protect forest resource

[2]Includes forests in Colorado, Kansas, Nebraska, South Dakota, and central and eastern Wyoming.

values. According to estimates from aerial and ground surveys, approximately 625,000 trees were infested on all ownerships.

Overstocked, mature, and dwarf mistletoe-infected trees on very rugged land of mixed ownerships along the Front Range of Colorado insure continued outbreak levels of mountain pine beetle. Suppression programs were conducted in specified forested urban areas. Suppression methods included chemical treatment, limited removal of firewood, and some timber sales.

In Wyoming, mountain pine beetle infestations increased in new locations along the eastern slope of the Bighorn Mountains on lands of all ownerships. Infestation on the Pine Hills, near Midwest, Wyo., remained at a high level. Suppression of the beetle on these areas of infestation was not feasible because of limited access.

Mountain pine beetle infestations in lodgepole pine in the Middle Park region of Colorado and on the Medicine Bow National Forest in Wyoming decreased. These populations were 50 percent lower than in 1975.

The infestation on the southern portion of the Shoshone National Forest and on National Resource Lands adjacent to the National Forest remained high. A cooperative timber sale was expected to remove 50,000 infested trees, and additional sales were planned to reduce the loss of green merchantable timber as the beetle population expanded beyond the sale boundary.

Regionwide, about 1,200,000 acres were infested by mountain pine beetle.

Spruce beetle, *Dendroctonus rufipennis* (Kby.). Spruce beetle activity in the Region was endemic. The principal areas of mortality were near timber sales and did not present any serious threats to surrounding spruce stands. Ski areas, particularly those that had cut new runs through spruce stands, were surveyed, but no beetle problems were found.

Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. In previous years, this insect has caused heavy mortality of commercial size Douglas-fir in Colorado and Wyoming. No large areas of beetle activity were found in 1976. Small groups of trees were reported on steep slopes of the Bighorn National Forest, but the infestations were considered static to decreasing.

Ips beetles, *Ips kanusi* Sw., and *Ips pini* Say. These insects were found in ponderosa pine on the San Juan National Forest. *I. pini* was reported on jack pine in Garfield, Dawes, and Sheridan Counties of Nebraska. *Ips* spp. was also found in Coal Creek Canyon, Colo.

Western spruce budworm, *Choristoneura occidentalis* Free. Defoliation of Douglas-fir and true fir by western spruce budworm was generally light in 1976. More acres of defoliation were reported in Colorado than in 1975, and defoliation was reported in Wyoming for the first time since 1962. Loss of merchantable Christmas trees occurred on the Arapaho, Roosevelt, Pike, and San Isabel National Forests because of the moderate and heavy defoliation. There were 497,000 acres of defoliation in Colorado and 20,500 acres in Wyoming.

In surveys conducted to determine parasitism within spruce budworm populations the majority of parasites known to attack spruce budworm in Colorado were recovered. Parasitism ranged from 8 to 51 percent of the larvae collected.

Parasitism was greater in the older infestations. *Phaeogenes hariolus* (Cress.), *Coccygomimus pedalis* (Cress.), and *Ceromasia* sp. (probably *auricauda*) were more common than *Glypta fumiferanae* (Vier.) and *Apanteles fumiferanae* (Vier.) in some areas of the San Juan, Pike, and San Isabel National Forests.

Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.). This insect continued to be a problem on ornamental spruce in Denver and Colorado Springs, Colo. There was an average of 188 eggs per mass, and larval emergence averaged 9 percent. Emergence of an egg parasite, *Telenomus californicus* (Ashm.), averaged 10 percent. Parasitism by *T. Californicus* ranged from 4 to 90 percent.

Sawfly, *Neodiprion fulviceps* (Cress.). A 1,500-acre infestation in ponderosa pine was found on the Rosebud Indian Reservation in South Dakota. No parasites emerged from larvae and cocoons collected in the field and reared in the laboratory. Infestations of *N. fulviceps* complex were reported in Keith and Banner Counties, Nebr. The infestations were each less than 5 acres.

White fir needle miner, *Epinotia meritana* Hein. The infestation of white fir needle miner remained at severe levels near LaVeta Pass in Colorado. New areas of infestation were found on the Blanco Trinchera lands west of LaVeta Pass. The infestation totaled about 8,500 acres, an increase of 1,500 acres over 1975.

Zimmerman pine moth, *Dioryctria zimmermani* (Grote). This insect caused severe damage on ornamentals and in shelterbelts of Box Butte, Brown, Dawes, Garfield, Hayes, Holt, Lincoln, Logan, and Valley Counties in Nebraska.

Tent caterpillars. These insects were common throughout the Front Range. Roadside surveys on the Boulder Ranger District, Roosevelt National Forest, showed fewer tents this year than in 1975. Two species were found this year, *Malacosoma californicum* (Pack.) and *M. incurvam discoloratum* (Neum.). The parasites *Rogas* spp. and *Bracon* spp. were common in the Pike and San Isabel National Forests collections and *Hyposoter* spp. were common in the Arapaho and Roosevelt

National Forests collections. An unidentified tachinid fly was rare in all collections. Overall, parasitism was low.

Elm leaf beetle, *Pyrrhalta luteola* (Mull.). Continuing heavy defoliation of elms occurred throughout Region 2 in urban areas and in shelterbelts of the Plains States. In the urban areas the beetle was primarily a nuisance.

Other insects. Other insects reported in 1976 included: spruce needle miner, *Taniva albolineana* (Kear.), and a pitch nodule moth, *Petrova* sp., which caused minor damage on ornamentals in Nebraska; and the greenstriped mapleworm, *Anisota rubicunda* (F.), which caused severe damage to maples near Omaha, Nebr. The pine needle miner, *Contarinia coloradensis* Felt., declined on ponderosa pine near the towns of Boulder and Black Forest, Colo. Light to moderate damage of ponderosa pine caused by tip moths, *Rhyacionia* spp., occurred throughout Region 2. A pine tortrix, *Choristoneura lambertiana ponderosana* Obraztsov, was observed in Colorado. Damage by aspen leaf miner, *Phyllocnistis populiella* Chamb., increased in the northern Black Hills of South Dakota. Cottonwood leaf beetle, *Chrysomela scripta* (F.); western pine shoot borer, *Eucosoma sonomana* (Hein.); and a pitch nodule moth, *Petrova arizonensis* (Hein.), were reported in Colorado. Red turpentine beetle, *Dendroctonus valens* LeC., hickory leaf and petiole gall aphid, *Phylloxera* spp., and a cottonwood leaf miner, *Agromyza populoides* Spen., were reported in Nebraska. A pitch nodule moth, *Petrova luculentana* (Hein.), and hackberry nipplegall maker, *Pachypsylla celtidismamma* Rly., were reported in South Dakota.

Status of Diseases

Dwarf mistletoe, *Arceuthobium* spp. Preliminary surveys were conducted in the Colorado Front Range to determine if southwestern dwarf mistletoe, *Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawks. and Wiens, predisposes trees to attack by the mountain pine beetle. The beetles prefer large diameter trees and those with a high dwarf mistletoe infection rating.

A new record for the extension of the range of lodgepole pine dwarf mistletoe, *Arceuthobium americanum* Nutt. ex Engelm., on lodgepole pine was found in the Green Mountains of Wyoming where the condition was very common. Limber pine dwarf mistletoe, *Arceuthobium cyanocarpum* Coul. and Nels., was found on limber pine in the Seminole Mountains and Crooks Mountains of Wyoming, and in Red Canyon of the Park Range in Jackson County, Colo. Damage was very severe, causing increased pine mortality. Pinyon dwarf mistletoe, *Arceuthobium divaricatum* Engelm., was found in Rio Blanco, Colo., 13 miles southeast of Rangely, extending to the known northern limit.

Comandra blister rust, *Cronartium comandra* Pk. The impact of this disease on 49 lodgepole pine stands was studied to determine the potential timber yield for pole or smaller size lodgepole pine. Only stands having 10 percent or more rust incidence were sampled. The most obvious damage was spike top trees. Data analysis would determine disease impact on growth and yield, and be used to develop silvicultural guidelines for managing rust infected stands.

Dutch elm disease, *Ceratocystis ulmi* (Buism.) C. Mor. Dutch elm disease was still the most destructive vascular wilt disease of American elms in this Region. The disease has been found throughout Kansas, Nebraska, and South Dakota, both in forests and urban areas. Its occurrence was reported in two additional counties, Fall River and Walworth, in South Dakota.

Oak wilt, *Ceratocystis fagacearum* (Bretz) Hunt. The occurrence of oak wilt was confirmed in Linn and Cherokee Counties in Kansas.

Foliage diseases. Diplodia tip blight, *Diplodia pinea* (Desm.) Kickx. The eastern one-third of Nebraska was surveyed for *D. pinea*, and the fungus was present in all 44 counties surveyed. Douglas-fir needle cast, *Rhabdocline pseudotsugae* Syd., was detected on Douglas-fir near Woods Landing on the Medicine Bow National Forest, Wyo.

Shoestring root rot, *Armillariella mellea* (Vahl. ex Fr.) Karst. Managed ponderosa and lodgepole pine stands in the San Juan, Rio Grande, Routt, and Arapaho National Forests, that have been commercially or precommercially thinned 5 to 15 years ago, had several centers of *A. mellea*. The disease dramatically reduced the stocking in some stands. Scattered mortality due to *A. mellea* was also noted in white fir, subalpine fir, Englemann spruce, limber pine, and Douglas-fir. *A. mellea* was isolated from Rocky Mountain juniper north of Cotopaxi, Colo. This was a new host record for the United States.

Nursery problems. Damping-off and bird predation were still the major cause of seedling mortality. *Fusarium* spp. caused a cortical rot of containerized Douglas-fir, Englemann spruce, and pinyon pine.

Other diseases. Ten acres of aspen along Clear Creek near Silver Plume, Colo., were infected with *Ceratocystis* sp., *Cenangium* sp., and *Hypoxylon* sp. cankers. Trees uphill from the creek bottom were less severely affected.

Pockets of dead and dying subalpine fir were noted on high elevation mountain passes in northern Colorado

in 1976. Western balsam bark beetle, *Dryocoetes confusus* Sw., galleries and an associated brown stain fungus were apparently the primary cause of death of the trees. Most isolations from the stain yielded a species of *Ceratocystis.*

An area of 300 to 400 acres of overmature lodgepole pine in the vicinity of Round Park in the Green Mountains of Wyoming was found to be infected with tumors of an unknown cause. Lodgepole pine and limber pine of all ages were affected. Tumors usually were grouped along trunks and branches. Hundreds occurred on individual trees. Similar appearing tumors were reported on lodgepole pine, limber pine, Douglas-fir, and subalpine fir by Peterson in 1961. [3] Insects are suspected of initiating the damage; however, this had not been confirmed.

Over 2,500 container-grown ponderosa pine seedings were inoculated with three species of ectomycorrhizal fungi at the Colorado State University Forest Service greenhouse. *Pisolithus tinctorius* (Pers.) Coker & Couch, *Cenococcum graniforme* (Sow.) Ferd. & Winge, and *Suillus granulatus* (L. ex Fr.) O. Kuntze, were used. These seedlings would be outplanted the following spring to evaluate the effects of ectomycorrhizae on field planting survival and growth. An examination of outplanted ponderosa pine seedlings infected with *P. tinctorius* indicated a 2.5-fold increase in field survival over nonmycorrhizal seedlings.

A sudden freeze and snowfall on June 14-15, caused extensive foliage damage to aspen, Gambell oak, white fir, Englemann spruce, lodgepole pine, limber pine, and subalpine fir. Drought caused wilting of American elms in Wyoming, which in turn caused confusion in identifying Dutch elm disease. Weather problems in Nebraska included scorch on hardwoods and winter desiccation in conifers.

SOUTHWESTERN REGION (R-3)[4]

by

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Conditions in Brief

Bark beetles depleted ponderosa pine, Douglas-fir, and spruce stands in Region 3 again this year. A mountain pine beetle infestation on the Kaibab National Forest and the Grand Canyon National Park, Ariz., caused scattered mortality over 75,000 acres of ponderosa pine type. Suppression efforts in 1975 and 1976 helped reduce local populations. The Douglas-fir beetle caused localized Douglas-fir mortality throughout Region 3. Tree mortality was heaviest on dry sites where Douglas-fir dwarf mistletoe was abundant or where trees had been weakened by fire. The Englemann spruce beetle continued to cause spruce mortality over 75,000 acres in the Jemez Mountains, Santa Fe National Forest, N. Mex.

The number of ponderosa pines killed by the roundheaded pine beetle, western pine beetle, and southern pine beetle decreased in 1976; *Ips* beetle infestations remained about the same as the previous year.

Defoliators increased in 1976. The western spruce budworm caused visible defoliation over about 124,000 acres of fir type, Regionwide. Douglas-fir tussock moth populations continued to increase on National Forest lands in Arizona and New Mexico. These populations were expected to continue increasing in 1977. Chronic tussock moth infestations continued on ornamentals in Santa Fe, Los Alamos, and Ruidoso, N. Mex. Defoliation of aspen stands by the western tent caterpillar in the Southwest generally declined in 1976. Some locally severe infestations still existed in northern Arizona and New Mexico. A 6,000-acre infestation of the New Mexico fir looper collapsed in 1976.

The southwestern pine tip moth continued to damage ponderosa pine reproduction in Arizona. However, as trees grow taller damage caused by this insect decreases.

Other insects causing noticeable tree damage in Region 3 included the large aspen tortrix, twig-boring beetles, pine sawfly, needle miners, and tip moths.

Dwarf mistletoes were again the most destructive pathogens in southwestern forests. Growth reduction and tree mortality caused by southwestern dwarf mistletoe on ponderosa pine was estimated to result in a volume loss of 150 million board feet annually. A major effort was made to improve management of dwarf mistletoe-infested stands through use of the simulated yield program SWYLD2. Over 10,000 acres of mistletoe-infected ponderosa pine stands had been surveyed, and control strategies were being developed for these areas. Heavy tree mortality continued to occur in stands infested by Douglas-fir dwarf mistletoes. Salvage logging and understory sanitation was recommended to reduce losses.

Black stain root disease, caused by *Verticicladiella wagenerii* Kend. was found infecting pinyon pine in three locations on or adjacent to the Jicarilla Ranger

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[3] Peterson, R. S. 1961. Conifer tumors in the Central Rocky Mountains. Plant Disease Reporter No. 45(6):472-474.

[4] Includes all forests in Arizona and New Mexico and National Park Service land in western Texas.

District, Carson National Forest, in northwestern New Mexico. Twenty to 100 trees per disease center were killed by *Verticicladiella*. This was the first record of black stain root disease in New Mexico. *Armillariella mellea* (Vahl. ex Fr.) Karst root rot continued to cause light tree mortality in ponderosa pine plantations in Arizona and New Mexico.

Abiotic diseases, such as hail damage, drought stress, and chloride toxicity from highway deicing salt resulted in substantial growth loss or tree mortality in localized areas in the Southwest.

Status of Insects

Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.). Two new Douglas-fir tussock moth outbreak centers, of about 100 acres each, were found in Canyon del Aqua, Sandia Ranger District, Cibola National Forest; and in Medio Dia Canyon, Tesuque Ranger District, Santa Fe National Forest, N. Mex. The infestation in Trigo Canyon, Mountainair Ranger District, Cibola National Forest, was still at a high level.

Low populations, detected in 1974 in the Sacramento Mountains, Lincoln National Forest, N. Mex. and the Sierra Anchas, Tonto National Forest, Ariz., increased in 1976. Additional low populations were detected near Los Alamos; in Cochiti Canyon, Tesuque Ranger District, Santa Fe National Forest; and in the Pinal Mountains, Globe Ranger District, Tonto National Forest. This insect (fig. 3) was expected to increase throughout the Region in 1977.

Chronic infestations continued in ornamentals (mainly spruce) in Santa Fe, Los Alamos, and Ruidoso, N. Mex.

Studies to evaluate use of the Douglas-fir tussock moth pheromone to predict population trends were started in 1976 and will continue in 1977.

Western spruce budworm, *Choristoneura occidentalis* Free. Regionwide, defoliation of white fir and Douglas-fir increased from 9,843 acres in 1975 to 123,760 acres in 1976. Aerial surveys showed 94,840 acres of light defoliation, 26,080 acres of moderate, and 2,840 acres of heavy. Infestations expanded and intensified on the Kaibab Plateau, Kaibab National Forest, Ariz., and the Carson, Santa Fe, Cibola, and Gila National Forests in New Mexico. Infestations were expected to increase in 1977.

Western tent caterpillar, *Malacosoma californicum* (Pack). Aspen stand defoliation in the Southwest generally declined from 1975 to 1976, but there were some locally severe infestations in northern Arizona and New Mexico. In the Kaibab National Forest and Grand Canyon National Park, Ariz., most aspen stands, which are mixed with conifers, were heavily defoliated for a second year. Esthetics were adversely affected along the scenic highway leading to the North Rim of Grand Canyon National Park, but stands quickly refoliated. No tree mortality was observed. On the Santa Fe National Forest in New Mexico, light to moderate defoliation was detected on the Tesuque, Coyote, Espanola, and Jemez Ranger Districts. Again, no mortality was noted.

Figure 3.—Douglas-fir tussock moth larva.

Tent caterpillar infestations usually persist for 2 to 3 years and quickly decline. Tree damage rarely reaches a point where control is needed. Outbreaks had started to decline in Region 3, and further decreases were expected in 1977.

Southwestern pine tip moth, *Rhyacionia neomexicana* (Dyar). This insect damaged ponderosa pine regeneration on 26,000 acres of the Chevelon Ranger District, Apache-Sitgreaves National Forest, Ariz., but less severely than in previous years. This insect can cause up to 40 percent height growth loss in ponderosa pine. As tree height increases, however, all types of tip moth damage increases.

New Mexico fir looper, *Galenara consimilis* Hein. An infestation on 6,000 acres of the Lincoln National Forest, N. Mex., collapsed in 1976. Two years of severe de-

foliation of Douglas-fir and white fir by this insect caused some mortality and top-kill of saplings throughout the infested area.

Mountain pine beetle, *Dendroctonus ponderosae* Hopk. This bark beetle continued to deplete ponderosa pine stands on the Kaibab National Forest and in Grand Canyon National Park in northern Arizona. Scattered tree losses were detected over 75,000 acres during the 1976 aerial detection survey. Strip cruises and stand surveys were made at the southern end of the infestation from Tater Ridge to Dog Lake where the heaviest concentrations of fading trees were found. No large groups (25 or more trees) of currently infested trees were found in these areas. Due to the widely scattered infestation elsewhere on the Forest, no concentrations of dead trees were expected. Beetle broods in newly infested trees were healthy and in the infestation was expected to continue. Tree losses were expected to be scattered over about the same 75,000-acre area infested in 1976.

In Grand Canyon National Park, the infestation was scattered, but tree losses increased from the previous year. Highly susceptible, sawtimber stands occur from Castle Canyon to Highway 67 leading to the North Rim of the Grand Canyon. There was a high probability that tree losses would increase in this area the following year.

In northern New Mexico, scattered infestations continued on the Carson and Santa Fe National Forests. The mountain pine beetle in New Mexico prefers overmature trees; whreeas relatively healthy trees were killed in northern Arizona. On the Carson National Forest, light infestations have been detected for several years on the Penasco, Taos, Tres Piedras, Canjilon, and El Rito Ranger Districts. Yearly population fluctuations have occurred, but the infestations do not require control yet.

Spruce beetle, *Dendroctonus rufipennis* (Kby.). A 75,000-acre infestation in the Jemez Mountains of the Santa Fe National Forest, N. Mex., continued in 1976, but was less severe than reported in 1975. During 1976, sanitation and salvage logging operations removed about 12 million board feet of infested and susceptible Engelmann spruce.

An infestation in a portion of the White Mountains, Fort Apache Indian Reservation, Ariz., declined to near endemic levels. Salvage logging of wind-thrown trees and treatment of green slash to prevent spruce beetle population increases were recommended.

Infested, downed spruce in the Arizona Snow Bowl, Coconino National Forest, Ariz., resulted from windthrow and ski-run construction. Bark on the infested bolts and stumps was peeled and burned to control the beetles.

Roundheaded pine beetle, *Dendroctonus adjunctus* Blandf. Ponderosa pine mortality caused by this insect in the Sacramento Mountains of the Lincoln National Forest and adjoining Mescalero Apache Indian Reservation, N. Mex., was considerably less in 1976 than in 1975. Pole-size trees were most commonly attacked. Since there are few markets in this area for pole-size material, opportunities for salvaging infested trees are limited.

Western pine beetle, *Dendroctonus brevicomis* LeC. Scattered, mature ponderosa pines, singly and in small groups, were killed by this bark beetle on all forests in the Southwest. Tree mortality was noticeably less than in 1975 on the Pleasant Valley Ranger District, Tonto National Forest; Santa Catalina Ranger District, Coronado National Forest; Prescott National Forest; and Hualapai Mountains, Ariz.

Southern pine beetle, *Dendroctonus frontalis* Zimm. Scattered ponderosa and Chihuahua pines in the Santa Catalina Mountains, Coronado National Forest, Ariz., were killed by this insect in 1976.

Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. Infestations of this bark beetle were greatest on the Alpine, Black River, and Springerville Ranger Districts, Apache-Sitgreaves National Forest, Ariz.; the Black Range and Glenwood Ranger Districts, Gila National Forest, N. Mex.; and Pecos Ranger District, Santa Fe National Forest, N. Mex. Tree mortality was heaviest in stands on dry sites where Douglas-fir dwarf mistletoe was abundant or where trees had been weakened by fire.

Ips beetles, *Ips* spp. Ponderosa pine losses in the Southwest from species of Ips beetles were about the same in 1976 as in 1975. No large centers of mortality were observed. Scattered tree losses were detected throughout the ponderosa pine type in Arizona and New Mexico. Most of the tree mortality occurred on marginal growing sites for ponderosa pine where stands were heavily infested with dwarf mistletoe.

Other insects. The large aspen tortrix, *Choristoneura conflictana* (Wlk.), caused some defoliation to aspen stands on parts of the Kaibab Plateau, Kaibab National Forest, Ariz. This insect worked in association with the western tent caterpillar in many stands. Twig boring beetles, *Pityophthorus* Spp., caused noticeable twig mortality to ponderosa pines on portions of the Long Valley and Mormon Lake Ranger Districts, Coconino National Forest, Ariz.; Reserve, Luna, and Quemado Ranger Districts, Gila National Forest, N. Mex.; and to pinyons in Chisos Basin, Big Bend National Park, Tex. Pine sawflies, *Neodiprion* spp., damaged ponderosa pines in limited areas of the Magdalena Ranger District, Cibola National Forest, N. Mex.; Williams Ranger District, Kaibab National Forest, Ariz.; and Long Valley

Ranger District, Coconino National Forest, Ariz. Damage from needle-mining moths, *Coleotechnites* spp., was evident between Luna and Reserve, N. Mex.; on the Gila National Forest; and around Indian Pine, Ariz., on the Fort Apache Indian Reservation. Approximately 1,200 acres of pinyon were damaged by tip moths on the Navajo Indian Reservation, east of Kalgetoh, Ariz. Old needle loss, due to larval mining, ranged from 50 to 90 percent. Loss of new terminals and laterals was estimated to be 25 to 50 percent.

Status of Diseases

Dwarf mistletoe, *Arceuthobium* spp. Dwarf mistletoe was the most damaging disease in commercial forests of the Southwest. Greatest timber volume losses were caused by the following species of dwarf mistletoe: *Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawks. and Wiens on ponderosa pine, *A. douglasii* Engelm. on Douglas-fir, *A. microcarpum* (Engelm.) Hawks. and Wiens on Engelmann spruce, and *A. apachecum* Hawks. and Wiens on southwestern white pine.

Implementation of the simulated yield program for dwarf mistletoe-infected ponderosa pine (SWYLD2) continued in 1976. About 10,000 acres of infested ponderosa pine stands were surveyed on four National Forests (Apache-Sitgreaves, Gila, Kaibab, and Santa Fe) and the Navajo Indian Reservation. Information gathered in the surveys was to be used to assist land managers in developing mistletoe control strategies.

Tree mortality caused by Douglas-fir dwarf mistletoe was common in the southern half of New Mexico and Arizona. Mixed conifer stands on the Apache-Sitgreaves National Forest sustained heavy growth losses, particularly where Douglas-fir and western spruce dwarf mistletoes both occurred in the same area.

Ponderosa pine trees were heavily infected by southwestern dwarf mistletoe in plantations on the Kaibab National Forest and the Mescalero Apache Indian Reservation.

Shoestring root rot, *Armillariella mellea* (Vahl. ex Fr.) Karst. This disease was evaluated on the Los Conchas, Roger, and Fenton plantations of the Santa Fe National Forest. A few fading trees were observed in the Los Conchas plantations, while the remaining plantations showed no new infection. *A. mellea* root rot was found in several other plantations throughout Region 3, as well as in natural stands; however, the disease was endemic in all situations.

Black stain root rot, *Verticicladiella wagenerii* (Kend.). This disease was found in three pinyon pine stands on or adjacent to the Jicarilla Ranger District of the Carson National Forest. Mortality occurred in pockets of 20 to 100 trees.

Foliage diseases. Foliage diseases, caused by *Elytroderma deformans* (Weir) Dark., *Lirula abietis-concoloris* (Mayr. ex Dearn.) Dark., and *Rhabdocline pseudotsugae* Syd., remained endemic throughout the Southwest.

Rusts. Limb rust, caused by *Peridermium filamentosum* Pk., remained at an endemic level in ponderosa pine forests of the Southwest.

Spruce broom rust, caused by *Chrysomyxa arctostaphyli* Diet., remained at an endemic level in spruce-fir forests of the Southwest. Fir broom rust, caused by *Melampsorella caryophyllacearum* Schroet., was endemic through most of Region 3. However, the fir broom rust infestation on white fir in the Sandia Mountains, east of Albuquerque, N. Mex., reached epidemic proportions. Infected trees often have 10 to 20 broom and bole infections. Recreational constraints have prohibited logging to control this disease in the Sandias.

Trunk and heart rots. A heart rot caused by *Echinodontium tinctorium* (E&E) E&E was frequently found on white fir and Douglas-fir in the Carson, Santa Fe, and Apache-Sitgreaves National Forests. This disease was very common in mature to overmature mixed conifer stands.

Trunk rots, such as *Polyporus anceps* Pk., *Polyporus volvatus* Pk., and *Fomitopsis pinicola* (Sw. ex Fr.) Karst., remained endemic throughout Region 3.

Nursery diseases. Planting stock delivered to the Lincoln National Forest and the Mescalero Apache Indian Reservation was injured by several species of mold. Ponderosa pine and southwestern white pine 1-0 and 2-0 stock was injured by molds while in storage before outplanting. Seedling mortality resulted from some mold infections, although most trees were culled before outplanting began. Infection by molds resulted from improper storage and handling of seedlings.

Aspen diseases. Aspen stands have been damaged perennially by stem and canker rot organisms. However, the most prevalent injury on aspen is a wound caused by elk "barking."

Salt damage. Roadside tree mortality caused by chloride toxicity from deicing salt increased in several areas of New Mexico. Heavy tree mortality occurred along the road to Santa Fe ski area. Tree species affected include ponderosa pine, southwestern white pine, Douglas-fir, white fir, Engelmann spruce, and aspen. Chloride toxicity also resulted in moderate roadside tree mortality near Los Alamos, N. Mex.

Weather damage. About 300 acres of ponderosa pine, pinyon, and juniper trees were severely damaged by a hail storm on the Navajo Indian Reservation in early

1976. Heavy defoliation, wounding on twigs and branches, and terminal leader mortality were prevalent on affected trees.

Tree mortality caused by drought stress was reduced from 1975 levels. Scattered ponderosa pine trees throughout Region 3 died from drought-related causes. Drought stress predisposes trees to secondary insect attacks or acts in combination with dwarf mistletoe infection to cause tree mortality.

INTERMOUNTAIN REGION (R-4)[5]

by

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Conditions in Brief

The mountain pine beetle was the most damaging insect in Region 4. Overall, the infestation trend was declining; however, localized portions of the Targhee National Forest in Idaho and the Ashley National Forest in Utah experienced increased bark beetle activity. Douglas-fir beetle infestations increased on the Boise and Sawtooth National Forests, but decreased in the rest of Region 4. There were scattered or localized infestations of the pine engraver beetle, spruce beetle, and western pine beetle.

Western spruce budworm infestations increased in Idaho and Wyoming. New defoliation was recorded in Douglas-fir and true fir stands on portions of the Boise and Payette National Forests in Idaho and on the Bridger-Teton National Forests in Wyoming. The Douglas-fir tussock moth caused light to moderate defoliation on about 10,000 acres of Douglas-fir and subalpine fir in Owyhee County, Idaho. There were localized infestations of fall cankerworm, western tussock moth, and white fir needle miner.

The forest disease situation was little changed from 1975. The most important diseases in the Intermountain Region were the decays, root rots, and dwarf mistletoe. These take a large yearly toll, yet go largely unnoticed, because of their ever present nature.

[5]Includes forests in Utah, Nevada, southern Idaho, western Wyoming, and eastern California.

Status of Insects

Western spruce budworm, *Choristoneura occidentalis* Free. Defoliation caused by the western spruce budworm was recorded on more than 1 million acres of Douglas-fir and true-fir type in Idaho and Wyoming. The oldest and heaviest concentrations of damage occurred on the Payette, Boise, Salmon, and Challis National Forests in Idaho. Defoliation on the Payette National Forest totalled about 810,000 acres, and increased in the South Fork of the Salmon River, in areas west of Cascade Reservoir, and in the Boulder Creek drainage northwest of McCall, Idaho. The Brundage Mountain area north of McCall was defoliated again in 1976. Light to heavy defoliation on the Boise National Forest occurred over about 98,000 acres, and extended below Sagehen Reservoir. It was recorded for the first time in areas southeast of Cascade Reservoir. Defoliation on the Salmon National Forest occurred in the upper Yellow Jacket drainage and in Shovel Creek.

Light to heavy defoliation, amounting to about 40,000 acres, occurred at three locations of the Targhee National Forest in Idaho and Wyoming. This included approximately 22,000 acres of Douglas-fir type on the slopes of the Centennial Mountain near Spencer, Idaho; 5,300 acres of Douglas-fir and subalpine fir type along the west side of Henry's Lake; and 12,000 acres of mixed type in the Snake River Canyon.

Defoliation on the Bridger-Teton National Forest, amounting to about 112,000 acres, increased in extent and intensity in 1976. Infestation centers included a 59,000-acre area extending from the Jackson Hole Elk Refuge, south 25 miles, to the headwaters of Willow Creek; and portions of the lower Hoback, lower Greys, and most of the Little Greys drainages encompassing about 53,000 acres.

During the spring of 1976, the weather was considerably cooler and wetter than normal. This condition probably had some adverse effect on larval survival. However, the results of the 1976 egg mass survey indicated that populations would be high enough to cause light to heavy defoliation in most areas again in 1977.

The results of stand hazard evaluations on the Boise, Payette, Targhee, and Bridger-Teton National Forests indicated that no mortality of overstory trees had yet occurred. Cumulative damage, resulting in some top-killing of intermediate and suppressed overstory trees, and scattered mortality in trees less than 5" dbh, were not considered significant enough to warrant direct control in 1977.

Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.). Light to moderate defoliation of Douglas-fir and

subalpine fir was observed on about 10,000 acres of mixed ownership in the Boulder Creek, Sinker Creek, and Jordan Creek drainages, Owyhee County, Idaho.

Ground samplings in early July revealed a high incidence of polyhedral virus in larval populations. The results of a fall egg mass survey indicated that larval populations would be low in 1977.

Use of the Douglas-fir tussock moth sex attractant to determine the geographic distribution of the insect in the the Intermountain Region in 1976 resulted in the detection of 22 male moths from 43 trapping sites on 12 National Forests. Forests on which one or more moths were detected include the Boise, Challis, Payette, Sawtooth, and Targhee National Forests in Idaho and the Manti-La Sal, Uinta, and Wasatch National Forests in Utah.

Fall cankerworm, *Alsophila pometaria* (Harr.). Moderate to heavy defoliation caused by the fall cankerworm was again reported in lower Corn Creek, Fishlake National Forest, Utah and along the Wasatch Front between Odgen and Salt Lake City, Utah. The heaviest defoliation occurred on box elder and Gambel oak with only light to moderate defoliation on big tooth maple and choke cherry. No permanent damage was observed after 3 years of consecutive defoliation in either area. The trend of the outbreaks is unknown.

Western tussock moth, *Orgyia vetusta gulosa* (Hy. Edw.). Defoliation of ceanothus and other broad leaf species by the western tussock moth occurred on the Idaho City and Lowman Ranger Districts, Boise National Forest. Defoliation of ponderosa pine saplings was observed in a plantation which contained infested ceanothus ground cover.

White fir needle miner, *Epinotia meritana* Hein. Light to heavy defoliation of white fir occurred on 3,400 acres in several locations on the Dixie National Forest, adjacent to Bryce Canyon National Park, along the East Fork of the Sevier River. The trend of the infestation is unknown.

Mountain pine beetle, *Dendroctonus ponderosae* Hopk. The mountain pine beetle continued to be the most damaging insect in Region 4 during 1976 with 756,600 acres included within the infested area. The trend of the infestation, Regionwide, has been decreasing for the past few years; however, several areas still experienced heavy mortality.

The largest infestation was located on the northern portion of the Targhee National Forest in Idaho. In the Island Park area the number of infested trees per acre increased from 20 in 1975, to 30 in 1976. Near Sawtell Peak, the increase was from 10 to 20. On the Moose Creek Plateau mortality continued, but at a much lower rate. Extensive timber harvesting in this area had utilized much of the threatened timber.

Increased bark beetle activity occurred on the Ashley National Forest, Utah. A marked increase in new attacks was recorded in lodgepole pine type at several locations east of Charley's Park, and in the vicinity of Red Cloud Loop north of Vernal. In ponderosa pine type, tree mortality increased at several locations in the vicinity of Greendale Junction on the west side of Flaming Gorge.

The infestations on the Cassia Division of the Sawtooth National Forest in southern Idaho appeared to be declining after killing nearly one-third of an estimated 384 million board feet of standing lodgepole pine. Annual losses appeared to be occurring at a decreasing rate.

Mortality in second growth ponderosa pine stands occurred on the Dixie National Forest in Utah. The largest infestations were recorded in the Table Cliff area near Pine Lake; in Water Canyon and Cherry Hollow near Green Guard Station; and throughout the Aquarius Plateau from North Creek to Bear Creek.

Infestations in Jeffrey pine continued in many widely scattered locations on the Toiyabe National Forest, Calif. The heaviest concentrations occurred south of Lake Tahoe in the Grovers Hot Springs and Markleeville areas, and on the East Fork of the Carson River.

Elsewhere in the Region, mountain pine beetle mortality was recorded on the Boise, Payette, and Caribou National Forests in Idaho, on the Bridger-Teton National Forest in Wyoming, and the Cache and Wasatch National Forests in Utah.

A preventive spray pilot study was conducted in stands along the lower Sawtell Peak road on the Targhee National Forest in 1976. This study was similar to the 1975 project, except that water formulated sprays were used rather than oil. Three chemicals, Lindane, carbaryl, (Sevimol-4^{R}), and Dursban^{R}, were tested at a 2 percent concentration by weight. Preliminary results indicated a protection level ranging from 23 percent to 98 percent for Dursban and Sevimol-4, respectively. Lindane provided 76 percent protection (fig. 4).

Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. Douglas-fir beetle infestations occurred on all National Forests in Idaho and Wyoming on about 405,800 acres. The heaviest infestation was on the South Fork of the Payette River from Lowman to Grandjean in the Boise National Forest. Infestations increased on the Fairfield Ranger District of the Sawtooth National Forest. Heavy mortality also occurred in portions of the Big Water Creek drainages. These areas had been defoliated by the Douglas-fir tussock moth in 1973 and 1974. Infestations occurred along the Salmon River and on the Challis Na-

Figure 4.–Mountain pine beetle population assessment following treatment with preventive spray.

tional Forest. Activity was decreasing on the Payette National Forest. Some scattered mortality occurred throughout the Targhee National Forest and on the Bridger-Teton National Forest south of the Jackson Hole ski area. Elsewhere in Region 4, activity decreased.

Pine engraver, *Ips pini* (Say). Pine engraver infestations were again observed in an area east of Bogus Basin, which has had chronic Ips infestations for the past 6 years. Elsewhere, Ips activity occurred in several timber sale areas on the Payette and Boise National Forests.

Spruce beetle, *Dendroctonus rufipennis* (Kby.). Spruce beetle continued at a very low level throughout the Intermountain Region in 1976. The heaviest mortality recorded was in Hintington Canyon on the Manti-La-Sal National Forest in Utah. Ground surveys indicated that populations were declining following a recent outbreak in that area.

Western pine beetle, *Dendroctonus brevicomis* (LeC.). Western pine beetle infestations in second growth ponderosa pine stands continued on portions of the Boise and Payette National Forests, Idaho. The heaviest damage occurred in overstocked pole and young sawtimber stands in the vicinity of Sagehen Reservoir on the Emmett Ranger District, Boise National Forest.

Black pineleaf scale, *Nuculaspis californica* (Cole.) A 400-acre ponderosa pine stand on private land near Genoa, Nev. was heavily infested for the third consecutive year. Repeated infestation resulted in scattered tree mortality and top and branch killing in individual trees. The results of population monitoring, May-July of 1976, indicated a recovering in parasite populations following the termination of a malathion mosquito abatement program. Population sampling will be conducted again in the spring of 1977 to determine parasite population and host tree recovery. A growth impact evaluation will also be started.

Status of Diseases

Dwarf mistletoe, *Arceuthobium* spp. Dwarf mistletoe, *Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawks. and Weins, on ponderosa pine was the most serious disease of Region 4. Dwarf mistletoe also damaged Douglas-fir, lodgepole pine, and larch. The Charter Mountain dwarf mistletoe suppression project on the Emmett Ranger District of the Boise National Forest was completed. The final phase consisted of selling merchantable infected ponderosa pine and felling, lopping, and scattering the remaining smaller trees. Direct control, consisting of cull tree removal and sanitation thinning of advanced regeneration, is expected to increase throughout the Intermountain States.

Annosus root rot, *Fomitopsis annosa* (Fr.) Karst. The number of forest stands known to be infested by this disease continued to increase. Detection surveys revealed many new infection centers on the Boise, Payette, and Salmon National Forests in Idaho. Nearly all new centers detected were located in areas where logging operations had been conducted during the past 15 years.

Dutch elm disease, *Ceratocystis ulmi* (Buism.) C. Mor. Dutch elm disease was not reported in any new areas this year. The disease had previously been detected in Ada, Canyon, and Payette Counties in Idaho.

Fir broom rust, *Melampsorella caryophyllacearum* Schroet. Broom rust of subalpine fir had been observed on State forest land near Swan Lake, Idaho during post-scale examinations on the Cottonwood Management Unit. The results of these examinations indicated that many residual trees were seriously infected with this rust and would possibly die before the next scheduled entry.

Stem canker, *Cytospora* sp. A stem canker of white fir caused by a *Cytospora* sp. was observed at several locations on the Escalante Ranger District, Dixie National Forest in southern Utah. Limb girdling, top-killing, and scattered tree mortality was commonly observed on white fir in dry site situations.

Air pollution. Broad-leafed and conifer vegetation, around the Navajo Generating Station at Page, Ariz. and the Huntington Canyon Generating Station south of Price, Utah, was examined for damage caused by release of SO_2 gas. No damage attributed to the effects of SO_2 had been found following 2½ years of exposure. No additional monitoring would be conducted unless damage was reported.

CALIFORNIA REGION (R-5)

by

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Conditions in Brief

In general, defoliator activity decreased or remained static at a low level in 1976. Two exceptions were the lodgepole needle miner and the Jeffrey pine needle miner; population densities of these two insects continued at outbreak levels through late summer. A small, established infestation of the gypsy moth, a destructive pest of fruit, shade, and forest trees in the East, was detected near San Jose, Santa Clara County. Some tree mortality caused by bark beetles was reported. Western pine beetle caused the most noticeable infestation in late 1976. The prospect for widespread tree mortality from bark beetles is increasing. Moisture stress, brought on by the 18-month-long drought in central and northern California, triggered sizeable increases in the number of bark beetle-killed trees.

Diseases in forest nurseries continued to be a major concern. *Rhizoctonia, Fusarium, Pythium,* and *Botrytis* were active in nurseries throughout the State. The incidence of Dermea canker increased, and the disease was reported in the Sierra Nevada forests. Lophodermella needlecast of sugar pine was reported widely throughout the northern part of the State. Ozone injury to ponderosa and Jeffrey pines was common in parts of the southern Sierra Nevada down from major urban centers.

In Hawaii, low rainfall continued to encourage disease and insect activity. An aerial survey program was initiated to assess forest pest problems.

Status of Insects—California

Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.). Douglas-fir tussock moth populations remained at endemic levels. The number of male moths caught in pheromone-baited detection traps on the Modoc, Stanislaus, and Eldorado National Forests was twice that reported in 1975; however, more work is needed before valid conclusions about population levels and trends can be drawn from the information. As in 1975, moths were caught at all of the trap sides.

Jeffrey pine needle miner, *Coleotechnites* sp. nr. *milleri* (Busck). The Jeffrey pine needle miner continued to infest some 3,275 acres of trees on the San Bernardino National Forest. The area of infestation increased approximately 5 acres since 1975. An evaluation of the needle miner is in progress.

Gypsy moth, *Lymantria dispar* (L.). An established infestation of the gypsy moth was discovered in Willow Glen (Santa Clara County), a suburb south of San Jose. This discovery marked the first time that an established gypsy moth infestation has been found in the Western United States. In Willow Glen, a single male moth was caught in a detection trap in 1975. In 1976, three additional separate trap catches were made. An intensive search for overwintering egg masses resulted in 250 viable egg masses being found on seven adjoining lots. The presence of cast larval skins, pupal cases, old egg masses, and verbal reports from local residents gave rise to speculation that the infestation may have become established as early as 1972, and has been intensifying and spreading since then. The California Department of Food and Agriculture began the necessary steps to decide the most appropriate actions to take.

Sawfly, *Neodiprion* spp. In 1976, two small centers of sawfly defoliation in white fir were reported in Placer County on the Tahoe National Forest. This compared with some 70 infestation centers in 1975.

Reports of sawflies defoliating pine in California are not common, since incidents have typically involved only a single tree or two in an isolated location. In 1976, however, colonies of sawflies were reported feeding on pine in six locations. In three of those locations, Long Valley in Mendocino County and Cedar Flat and Socker Creek in Siskiyou County, feeding injury was prevalent,

with 100, 1,000, and 10,000 plantation pine trees affected at each location, respectively.

Western pine beetle, *Dendroctonus brevicomis* LeC. Through mid-summer, western pine beetle infestation levels were static. By late fall, however, the severe drought experienced in northern California over the previous 18 months began to manifest itself, and the occurrence of fading ponderosa pine increased markedly. The increase was most noticeable in the lower elevation pine type of the Sierra Nevadas, and on the edges of the timber type, such as the upper elevation limit of the species, or on low-site chaparral fringes. Pronounced increases were reported at Camp Nelson and Bull Run Peak, Tulare County; Barnes Mountain, Fresno County; Elizabeth Peak, Twain Hart, and near Groveland, Tuolumne County; along Omo Ranch Road, El Dorado County; Ralston Ridge, Placer County; Burney-Hat Creek area, Shasta County; and McCloud Flats, Siskiyou County.

At McCloud Flats, beetle activity in the Edson Creek area appeared to be directly associated with the proliferation of black staining root disease. Further west on the Flats, in the thinned stands at Pilgrim Creek and Elk Springs, the incidence of root disease was low, as was the number of beetle-killed trees.

Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. Populations of the Douglas-fir beetle were low throughout 1976. As in 1975, no outbreaks were reported.

Flatheaded fir borer, *Melanophila drummondi* Kby. Quantitative data collected on the Klamath National Forest supported the 1975 report that there was increasing mortality in Douglas-fir in northwestern California. The flatheaded fir borer was present in a large portion of the dead and dying trees. Partial analysis of the data also indicated that stand and site conditions, the Douglas-fir beetle, and *Polyporus schweinitzii* Fr. root rot, working in conjunction with flatheaded borers, were the major contributors to the losses. Salvage logging to recover dead and dying Douglas-fir was the only action recommended.

Jeffrey pine beetle, *Dendroctonus jeffreyi* Hopk. Jeffrey pine beetles caused increased tree mortality in four locations in Fresno County, Plumas County, Lassen County, and Shasta County. Action to salvage infested trees was being considered or was in progress at all locations.

Fir engraver beetle, *Scolytus ventralis* LeC. Individual trees and tops killed by the fir engraver beetle were detected throughout much of the fir type. At one location, Franklin Creek drainage in Modoc County, damage was concentrated enough to make salvage a viable possibility.

Mountain pine beetle, *Dendroctonus ponderosae* Hopk. The mountain pine beetle infestation in lodgepole pine at Skunk Cabbage Creek in the southern Warner Mountains of Modoc County continued in 1976. At Parker Creek, an outbreak of mountain pine beetle caused tree mortality in stands of pole-size ponderosa pine. Salvage and thinning operations to increase the resistance of the residual stands were begun.

Other insects. Two infestations of black pineleaf scale, *Nuculaspis californica* (Cole.), that were very active in 1975, collapsed in 1976. Those infestations had been centered in the vicinity of Glenburn, Shasta County, and Surprise Valley, Modoc County. No major infestations or damage by pine engraver beetles, *Ips* spp., were reported in 1976. Some of the infestations that were reported could be traced directly to a disturbance, such as logging or fire. Larval sampling in June, and egg mass sampling in September, indicated that the infestations of Modoc budworm, *Choristoneura viridis* Free., on white fir in Modoc County had subsided to endemic levels. Douglas-fir gall midges, *Contarinia* spp., were active again in plantation Douglas-fir at several locations.

Injury to large numbers of pine trees in plantations was reported throughout the State. In most cases, the injury was caused by one or more of these insects; the pine needle sheath miner, *Zelleria haimbachi* Busck.; a pine resin midge, *Cecidomyia piniiopis* O.S.; and the ponderosa pine tip moth, *Rhyacionia zozana* (Kear.).

Status of Insects—Hawaii

Eurasian pine aphid, *Pineus pini* Koch. The pine aphid remained a problem on pine on the islands of Maui and Molokai. Efforts were made to establish natural enemies of this aphid. Two chamaemyiid flies, *Leucopis (Neoleucopis) obscura* Hal., and *L. nigraluna* McAlpine, from Pakistan; and a coccinellid, *Scymnus (Pullus) stuuralis,* were released.

Other insects. A scale insect, *Fiorinia fiorinia* (Targ.), was found infesting Monterey pine shoot tips on Molokai Island, a new island record. Fuller rose beetle, *Pantomorus cervinus* (Boh.), was found feeding on foliage of cork oak, Aalii *(Dondonaea viscosa* L.), and Monterey pine on Molokai island. The oleander hawk moth, *Deilephia nerii* (L.), was found feeding on Hao *(Rauvolfia sandwicensis* Gray) on the island of Hawaii.

Status of Diseases—California

Nursery diseases. Major losses of I-0 pine occurred at both Humboldt and Placerville sugar nurseries.

Twenty-three percent of the sugar pine trees planted in beds which were fumigated in the spring were killed by a complex of *Fusarium* spp. and a *Pythium/Phytophthora* complex. This complex caused a root rot in 3- to 4-month-old seedlings.

Forty-nine percent of the sugar pine and 16 percent of the Douglas-fir seedings at Placerville Nursery, Camino Tract, were killed by a *Rhizoctonia/Fusarium* complex.

Strains of *Botrytis cinerea* Pers. ex Fr. resistant to benomyl continued to be a major problem in nurseries producing containerized stock. *B. cinerea* was found in two nurseries where the tolerant strain had not previously existed.

Phoma spp. in 1-0 Douglas-fir, *Phomopsis Lokoyae* Hahn in 2-0 Douglas-fir, and *Sirococcus strobilinus* Preuss. in Jeffrey pine were found in the Humboldt Nursery, but caused little damage. At Placerville Nursery, a *Phytophthora* sp. was found in two beds of 2-0 sugar pine. Charcoal root rot caused by *Macrophomina phaseoli* (Maulb.) Ashby resulted in minor losses of true fir.

Root rots. *Fomitopsis annosa* (Fr.) Karst., *Armellariella mellea* (Vahl ex Fr.) Karst., and *Verticicladiella wagenerii* Kend. There were continued reports of annosus root rot in ponderosa and Jeffrey pine stands, and of *A. mellea* on Atlantic cedar, madrone, and Douglas-fir. Reports of mortality associated with *V. wagenerii* have increased markedly.

White pine blister rust. *Cronartium ribicola* Fisch and Waldh. Blister rust was reported throughout the State. Large, new infection centers were observed in sugar pine outplanting sites in Siskiyou County, and several new infection centers were reported in Tulare County. Infection of currants was extremely heavy in the northern counties during the summer.

Stem and branch cankers. *Dermea pseudotsugae* Funk was reported from State, private, and Federal forest lands in Del Norte, Humboldt, and Siskiyou Counties. Once reported primarily as a disease of plantations, the canker is now widespread in natural stands, affecting Douglas-fir saplings and young sawtimber.

Foliage diseases. Infection by *Lophodermella arcuata* (Dark.) Dark., a needle cast of sugar pine, was more widespread and severe in Plumas County than in 1975.

Air pollution. Ozone injury symptoms were common on ponderosa and Jeffrey pines along Highways 69, 180, and 198 from Pinehurst to near Big Baldy Ridge in Kings Canyon National Park, Fresno and Tulare Counties. At Big Stump Basin ozone injury was also observed on sugar pine and white fir.

The Forest Service, with the assistance of the University of California and the State Air Resources Board, monitored ozone at Whitaker's Forest in 1976. From mid-July through October, 93 percent of the total hours were monitored. The ozone dose detected was 564 parts per hundred million-hours (pphm-hrs) exceeding the Federal standard (8 pphm). This dose was sufficient to produce the symptoms observed on pines in Fresno and Tulare Counties, although it was well below the dose experienced in the San Bernardino Mountains, where severe ozone damage had occurred for many years.

Weather. Abnormally low precipitation during the winter of 1975-76, combined with sporadic summer rainfall throughout the northern part of the State, resulted in an overall water deficit that produced an unusual number of weather-related detection reports. Most of these were diagnosed as drought caused. The drought was expected to increase problems in the State for at least the next year, even with normal rainfall in 1977.

Status of Diseases—Hawaii

Ohia forest decline. Ohia forest decline remained the State's most destructive forest disease problem. Over 250,000 acres of ohia forests on the island of Hawaii were affected. The native cerambycid beetle may be one factor associated with the decline; also, the trees may be predisposed to beetle attack by the root rot fungus, *Phytophthora cinnamoni* Rands. Physical factors such as weather are also suspected. Researchers at the Institute of Pacific Islands Forestry are in the process of determining the role of the insect, disease, and environment in the cause of Ohio decline.

Diplodia tip blight. *Diplodia pinea* (Desm.) Kickx. This disease continued to be a problem on the islands of Molokai and Maui in Monterey and pinaster pine stands. The disease had taken its greatest toll on Molokai where 300 acres were infected.

PACIFIC NORTHWEST REGION (R-6)

by

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Conditions in Brief

Western spruce budworm and mountain pine beetle continued to be the most destructive insects in the Pacific Northwest. Western spruce budworm infestations in Washington increased significantly in size and intensity in mixed conifer stands in 1976. New defoliation was recorded in Douglas-fir and true fir stands on portions of the Okanogan and Wenatchee National Forests, the North Cascades National Park, and the Colville and Yakima Indian Reservations. In Oregon, the outbreak on the Warm Springs Indian Reservation continued at about the same intensity and size as in 1975. New defoliation was observed on the Malheur National Forest at Dixie Butte, northeast of John Day, Oreg. Mountain pine beetle continued to cause heavy mortality in lodgepole pine and ponderosa pine stands in eastern Oregon. Losses on the Umatilla, Wallowa-Whitman, and Malheur National Forests, and adjacent State and private lands increased. Elsewhere, mountain pine beetle losses were noticeable on the Wenatchee and Colville National Forests and surrounding State and private lands in Washington; and the Deschutes, Winema, and Fremont National Forests, and surrounding State and private lands in Oregon.

Douglas-fir beetle activity increased significantly on the Umatilla and Wallowa-Whitman National Forests. Losses were greatest in the general area defoliated by the Douglas-fir tussock moth in 1972, 1973, and 1974. Douglas-fir beetle losses also increased significantly on the Siuslaw, Umpqua, and Willamette National Forests, and surrounding lands in western Oregon.

Western pine beetle continued to cause heavy losses in ponderosa pine stands on the Malheur, Ochoco, Fremont, and Winema National Forests, and surrounding lands in eastern Oregon.

No Douglas-fir tussock moth defoliation was recorded in either State.

Needle diseases and root rots appeared to be the most obvious disease problems in 1976. *Lophodermella concolor* caused a needle blight of lodgepole pine seedlings and saplings over several thousand acres in eastern Oregon. Damage resulted primarily in growth loss with no mortality. *Rhabdocline pseudotsugae* was frequently observed causing a needle blight in westside Douglas-fir stands, especially in offsite trees. *Elytroderma deformans* continued to cause a needle blight in ponderosa pine in eastern Oregon and Washington. Branch dieback caused by *Cytospora abietis* was common on true firs in sections of central Oregon. Branch dieback and wilting of big-leaf maple (causes unknown) were also observed throughout western Oregon and Washington.

Black stain root disease caused by *Verticicladiella wagenerii* was observed causing mortality, mostly in Douglas-fir throughout western Oregon and Washington, but a few mountain hemlocks and ponderosa pines were also killed. *Armillariella mellea,* causing root rot over the entire Region 6, appeared more serious in eastside stands. *Phellinus weirii* was reported more frequently due to an increased awareness of the disease in the Region. *Phytophthora lateralis* continued its devastation in native Port-Orford cedar stands in southwestern Oregon . *Rhizina undulata,* the causal agent of root rot in Douglas-fir seedlings, appeared most damaging in Whatcom, Skagit, and Snohomish Counties of Washington.

Status of Insects

Western spruce budworm, *Choristoneura occidentalis* Free. Infestations of the western spruce budworm increased significantly in 1976. Approximately 1.1 million acres of Douglas-fir and true fir were defoliated to some extent this year. The majority of the defoliation occurred on the Okanogan and Wenatchee National Forests, adjacent State and private lands, and the North Cascades National Park in north-central Washington. Spruce budworm defoliation is summarized below.

	1975 Defoliation (Acres)	1976 Defoliation
Oregon	18,990	11,180
Washington	513,030	1,088,840
	532,020	1,100,020

Light defoliation was detected for the first time east of the Okanogan River. About 120 acres were defoliated on the Tonasket District, Okanogan National Forest, and 2,100 acres on the Colville Indian Reservation. Light to moderate defoliation, totaling about 3,310 acres occurred on the Yakima Indian Reservation in Washington. The outbreak on the Warm Springs Indian Reservation continued at about the same intensity and size as in 1975. A total of 10,800 acres was defoliated in 1976. A new outbreak of western spruce budworm was detected on 380 acres on the Malheur National Forest near Dixie Butte northeast of John Day, Oreg. The outbreak on the Wallowa-Whitman National Forest collapsed because a late frost in June killed most

of the new buds and shoots and consequently destroyed the food supply of the budworm.

A cooperative control project was conducted against the western spruce budworm on the Okanogan and Wenatchee National Forests, adjacent State and private lands, and the Warm Springs Indian Reservation in the summer of 1976. Approximately 358,000 acres were treated with malathion ULV concentrate containing 95 percent active ingredient, and a total of 7,664 acres were treated with Sevin 4 Oil[R] at the rate of 1 pound active ingredient in 32 ounces of formulated material.

Fall egg mass surveys, made in the treated and untreated areas, showed that the 1977 populations would be high in many areas, particularly in those that were not treated.

Modoc budworm, *Choristoneura virdis* Free. Populations of this insect continued to cause light defoliation of the Fremont National Forest and adjacent State and private lands in south-central Oregon. An estimated 5,600 acres of white fir were defoliated in the north Warner Mountains and northeast of Gearhart Mountain. A fall egg mass survey on State and private lands indicated that the budworm populations were static or declining. However, populations could still cause light defoliation in some areas in 1977.

Larch casebearer, *Coleophora laricella* (Hbn.) Populations of this insect continued to defoliate western larch stands in eastern Oregon and Washington. No formal aerial survey was made to determine the spread and damage of the insect in 1976; however, observations made in the field indicated that defoliation was at about the same low level reported in 1975.

The range of the casebearer had expanded throughout the range of western larch on the eastside of the Cascade Mountains in Washington. It was observed infesting western larch at Sheep Butte on the Yakima Indian Reservation. Casebearer population densities in this area were not high enough to cause defoliation visible from the air.

Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.). No defoliation caused by this insect was detected in either Oregon or Washington in 1976. However, individual larvae were recovered from defoliator monitoring plots on the Deschutes, Mt. Hood, Winema, Fremont, and Malheur National Forests in eastern Oregon, and the Colville Indian Reservation in northcentral Washington. Low populations were found for the sixth consecutive year at Mare's Egg Spring on the northwest side of upper Klamath Lake on the Winema National Forest.

Pine needle sheath miner, *Zelleria haimbachi* Busck. This insect caused severe damage to ponderosa pine plantations near Klamath Falls, Oreg. The outbreak has persisted for 3 consecutive years. Severe defoliation was caused by this insect on plantations of shore pine and other ornamentals in Multnomah County, Oreg.

Western oak looper, *Lambdina fiscellaria somniaria* Hulst. This insect defoliated isolated stands of Oregon white oak near Chehalis and Centralia, Wash. Moths were also taken in light traps near Salem, Oreg., but no defoliation was reported in Oregon this year.

Balsam woolly aphid, *Adelges piceae* (Ratz.). Damage caused by this insect occurred in true fir stands in western Oregon and Washington in 1976. No new outbreaks were detected in either State. However, some tree mortality was observed in subalpine fir stands infested with balsam woolly aphid on the Mt. Baker-Snoqualmie National Forest near Concrete, Wash. This outbreak was reported for the first time in 1975. No visible damage was observed in the Blue Mountains where the aphid was discovered in 1974.

Mountain pine beetle, *Dendroctonus ponderosae* Hokp. The mountain pine beetle continued to cause heavy mortality in Oregon and Washington. Mortality of lodgepole pine during 1976 was estimated at 152.8 million board feet on 1,168,550 acres. Major losses occurred on the Wallowa-Whitman, Umatilla, Fremont, Malheur, Deschutes, and Winema National Forests, and adjacent State and private lands in Oregon. In many of the areas where the insect had been epidemic for 7 or more years, almost all lodgepole pine trees over 4 inches in diameter have been killed. Elsewhere, scattered tree-killing was observed on the Ochoco, Rogue River, and Umpqua National Forests, Warm Springs Indian Reservation, and Crater Lake National Park in Oregon. In Washington, scattered losses were observed on the Wenatchee and Colville National Forests, and the Colville Indian Reservation.

Regionwide, mortality in ponderosa pine stands increased significantly with nearly 97 million board feet affected. The most striking losses occurred in mature and second-growth ponderosa pine stands on the Umatilla, Wallowa-Whitman, and Malheur National Forest, and adjacent State and private lands in eastern Oregon. Nearly 350,000 acres of the infested ponderosa pine was located within the larger 1-million-acre mountain pine beetle outbreak in the lodgepole pine stands southwest of LaGrande, Oreg. Losses in mature and immature ponderosa pine on National Forest lands in this area were estimated to be 60.1 and 11.4 million board feet, respectively.

Losses on adjacent State and private lands were 16.4 million board feet and 8.3 million board feet for mature and immature pine. Ground surveys indicated additional losses occurred as the insect continued to attack green

trees throughout the summer months.

Scattered losses were reported in sugar pine stands on the Rogue River, Siskiyou, Umpqua, and Winema National Forests. The trend of these outbreaks is unknown.

Mountain pine beetle losses in western white pine stands declined in 1976. Significant losses were observed, however, on the Wenatchee and Colville National Forests in Washington. An estimated 3.9 million board feet were killed on these two Forests in 1976.

Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. Losses caused by the Douglas-fir beetle increased more than fourfold in Oregon and Washington in 1976. The insect killed an estimated 67.7 million board feet of Douglas-fir on 189,160 acres in both eastside and westside forests. The most significant losses occurred on the Umatilla National Forest and adjacent State and private lands in eastern Oregon and Washington. On the Forest alone, an estimated 53.8 million board feet of Douglas-fir were affected. Most of this loss, 47.7 million board feet, was reported on the Walla Walla, Pomeroy, and Pendleton Ranger Districts. These areas were heavily defoliated by the Douglas-fir tussock moth in 1972, 1973, and 1974.

The Douglas-fir beetle also caused heavy losses on the Wallowa-Whitman National Forest in Oregon. The largest outbreak, involving about 1.6 million board feet of timber, was observed in the Hells Canyon Wilderness Area in the vicinity of the 1973 Freezeout Saddle Fire.

Scattered tree mortality was also observed on the Malheur, Rogue River, Siskiyou, Siuslaw, Umpqua, and Willamette National Forests in Oregon. In Washington, losses occurred on the Okanogan, Wenatchee, and Colville National Forests, and the Colville Indian Reservation.

Flatheaded fir borer, *Melanophila drummondi* (Kby.). Losses caused by this insect declined significantly in southwest Oregon in 1976. An estimated 8,290 acres of mortality in scattered pole-size Douglas-fir and ponderosa pine timber was found along the foothills of the Rogue and Umpqua River drainages in the vicinity of Medford, Grants Pass, and Tiller.

The sharp decline in losses from those reported the previous year was attributed to ample rainfall in the spring of 1975. Losses in 1977 should continue to decline since precipitation was near normal again in 1976.

Fir engraver, *Scolytus ventralis* LeC. Populations of this insect declined in Oregon and Washington in 1976. Losses in true fir stands were about 10.5 million board feet on 85,420 acres. Most of the damage occurred on the Fremont, Malheur, and Umatilla National Forests, adjacent State and private lands in Oregon, and on the Colville and Umatilla National Forests in Washington.

Spruce beetle, *Dendroctonus rufipennis* (Kby.). Spruce beetle activity declined in Oregon and Washington in 1976. Widely scattered patches of tree mortality in Engelmann spruce stands were reported on the Umatilla and Colville National Forests in Washington and on the Umatilla and Wallowa-Whitman National Forests in Oregon.

Western pine beetle, *Dendroctonus brevicomis* LeC. Western pine beetle infestations remained high throughout eastern Oregon and Washington in 1976. In Oregon, losses in mature and overmature ponderosa pine stands were estimated at 14.8 million board feet. The heaviest losses occurred on the Fremont, Malheur, and Ochoco National Forests, and adjacent State and private lands where an estimated 12.1 million board feet were killed.

Smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.). This insect was widespread throughout eastern Oregon. In western Oregon, the beetle was found throughout an area extending from Scappoose on the Columbia River, southward through the Willamette Valley to the Oregon border. The species' western boundary appeared to correspond roughly with the eastern foothills of the Coast Range. No beetles were found in any of the pheromone traps placed in the coastal counties.

Pine engraver, *Ips pini* (Say). Approximately 7,030 acres of ponderosa pine damaged by Ips were observed in Oregon and Washington in 1976. The heaviest damage was reported on the Malheur and Wallowa-Whitman National Forests and adjacent State and private lands.

Other insects. In Oregon, about 1,500 ornamental pines were treated for European pine shoot moth, *Rhyacionia buoliana* (Schiff.) in Woodburn, Marion County, and 3,000 ornamental pines were treated at Hermiston, Umatilla County, Oreg. All trees were treated with carbaryl. No infestations were found in forested areas. The webworm, *Hypantria cunea* (Drury), defoliated ornamental shade trees in Marion County, Oreg. Populations appeared to have increased. The two-lined larch sawfly, *Anaoploynx occidens* Ross., defoliated western larch in conjunction with larch casebearer southeast of La Grande, Oreg. A white fir sawfly, *Neodiprion abietis* (Harr.), was reported defoliating scattered white fir on State and private lands and on the Winema National Forest near Klamath Falls, Oreg.

Status of Diseases

Lodgepole pine needle cast, *Lophodermella concolor* (Dearn.) Dark. This disease was detected on several thousand acres of lodgepole pine in eastern Oregon from Prairie City to Ukiah to Troy. The fungus infects

current season's foliage, but the damage does not become visible until the following spring when the needles turn reddish brown. The disease appeared to be limited mostly to understory trees. Most of the infection occurred within 10 feet of the ground.

The above-average precipitation in the spring and early summer of 1975 and similar conditions in 1976 contributed to an increase in damage caused by other foliage diseases.

Douglas-fir needle cast, *Rhabdocline pseudotsugae* Syd. This disease was frequently observed in westside Douglas-fir stands. In many cases, offsite trees were the most severely damaged. Four stands near Cottage Grove, Oreg., were evaluated for infection. Six to 42 percent of the trees were infected.

Elytroderma needle blight, *Elytroderma deformans* (Weir) Dark. This disease continued to increase on ponderosa pine in eastern Oregon and Washington. This increase had been observed for about 3 years. Tree mortality has not occurred yet.

True fir branch dieback. Branch dieback was common on true firs in the areas between Bend and McKenzie Bridge, Oreg. Most of the dieback was caused by *Cytospora abietis* Sacc., a canker-forming fungus which infects the branch through dwarf mistletoe infections. In some cases, stressed trees also become susceptible to cytospora infection. The amount of infection was expected to remain about the same in future years.

Big-leaf maple dieback. Big-leaf maple throughout western Oregon and Washington was damaged by a disease of unknown cause. Damage appeared as branch dieback and wilting.

Black stain root rot, *Verticicladiella wagenerii* (Kend.). Trees were killed in numerous stands throughout western Oregon and Washington. Douglas-fir was most commonly infected, but the disease was also found on mountain hemlock and ponderosa pine. Practically all infection centers were in plantations.

Armillariella root rot, *Armillariella mellea* (Vahl. ex Fr.) Karst. Stands infected with *A. mellea* were observed over the entire Region 6. Damage was more serious on the eastside where approximately 2,000 acres located near the south boundary of Crater Lake National Park had been severely damaged. In this area, 25 percent of the volume of the stand had been killed. Similar areas could be found in eastern Oregon and Washington. Guidelines for treating Armillariella infected stands were being developed for foresters.

Laminated root rot, *Phellinus weirii* (Murr.) Gilb. This disease was responsible for increased mortality in Douglas-fir stands. Additional infection centers had been reported principally because foresters were becoming increasingly aware of the disease. Guidelines for preventing and reducing losses will be distributed soon.

Port-Orford cedar root rot, *Phytophthora lateralis* Tuck. and Mil. Native Port-Orford cedar stands in southwestern Oregon, as well as ornamental plantings in Oregon and Washington, were severely damaged by this root rotter. Management guidelines for this disease are being developed.

Rhizina root rot, *Rhizina undulata* (Fr.) Karst. Extensive Douglas-fir seedling mortality in a 1-year-old plantation near Gold Bar, Wash., in Snohomish County, was caused by *R. undulata.* This disease seems to be most damaging in the northern Washington Counties of Whatcom, Skagit, and Snohomish.

Dutch elm disease, *Ceratocystis ulmi* (Buism). C. Mor. Dutch elm disease infected about 90 percent of the elms in Union, Oreg. Other communities affected were Nyssa and Ontario. The Oregon State Department of Agriculture conducted surveys for detection of the bark beetle vectors, and evaluated treatments for elm protection.

White pine blister rust, *Cronartium ribicola* Fisch and Waldh. Western white pine and sugar pines are being evaluated for resistance to white pine blister rust at the Dorena Tree Improvement Center. This work has been in progress since 1956. Approximately 750,000 seedlings with high levels of resistance were grown in Forest Service nurseries. The resistance was holding up well in outplantings.

Other diseases. A basal canker of unknown cause was detected on several Douglas-fir seed orchard trees near Rochester, Wash. A similar canker had been reported on seed orchard trees in British Columbia.

SOUTHERN REGION (R-8)[6] AND SOUTHEASTERN AREA

by

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CONDITIONS IN BRIEF

Southern pine beetle populations continued to decline throughout the Atlantic Coastal Plain, Piedmont Region,

[6]Includes forests in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

and the southern Appalachian Mountains. In some localized portions of the central Appalachian Mountains, however, southern pine beetle populations remained high.

In the Gulf States, southern pine beetle populations reached epidemic levels in east Texas, Arkansas, Louisiana, southeast Oklahoma, and Mississippi. In eastern Texas over 11,000 active pine beetle spots of over 10 trees or more were reported. Thirty-six of 44 counties, including the Big Thicket National Preserve, were declared a disaster area because of beetle damage. Alabama was the only Gulf State to report endemic southern pine beetle population levels.

Light to moderate defoliation by the fall cankerworm occurred in North Carolina, Georgia, and Virginia. In Georgia and North Carolina, approximately 24,100 acres and 26,000 acres respectively, were defoliated.

Defoliation by the forest tent caterpillar was light to moderate in South Carolina and Kentucky. Heavy defoliation of water tupelo by the forest tent caterpillar in Alabama and Louisiana exceeded 9,160 and 300,000 acres, respectively.

Fusiform rust remained the most widespread and serious disease in the South. Resistance testing, as well as impact evaluation, continued in 1976.

The disease receiving the greatest attention in 1976 was pitch canker. This disease had been found in every county in Florida and at localized areas in several other States. *Fusarium moniliforme* var. *subglutinans* appeared to be the primary causal agent involved in the current outbreak.

Nursery diseases continued to cause significant damage in several southern nurseries. The major nursery diseases were root rots caused by black root rot, cylindrocladium root rot, and phytophthora root rot.

Tests of mycorrhizae continued to show promise. Dramatic increases were recorded in survival and growth of pines inoculated with mycorrhizal fungi.

Among the diseases of local importance in 1976, were annosus root rot, white pine blister rust, and oak decline.

Status of Insects

Southern pine beetle, *Dendroctonus frontalis* Zimm. Texas experienced one of the worst years in history for southern pine beetle activity. Thirty-six of the 44 counties with pine forests in eastern Texas were declared disaster areas because of southern pine beetle damage. Over 11,000 southern pine beetle spots of 10 trees or more were detected in east and southeast Texas. This was twice the number of the previous year. Of this total, 12 percent of the active spots were on National Forest lands, 43 percent were on individual private lands, and 45 percent were on industrial holdings. The areas of heaviest infestation occurred in southeast Texas near Beaumont and Sour Lake. Salvage volume of infested trees on all lands exceeded 35,501 cords of pulpwood and 16.26 million board feet of sawtimber.

In Arkansas, 20 counties in the southern portion of the State reported southern pine beetle activity. Heaviest activity was reported in the southwest, particularly in Lafayette and Little River Counties. Only light to moderate activity was reported from the southeastern part of the State in Union and Ashly Counties.

Southern pine beetle infestations continued to increase in the southeastern part of Oklahoma. Moderate to heavy southern pine beetle activity was reported in McCurtain, Pushmataha, and Choctaw Counties. Southern pine beetle activity in Louisiana was at an all-time high with 32 Parishes reporting southern pine beetle-caused losses (fig. 5). Parishes heaviest hit were DeSoto, Sabine, Vernon, Beauregard, and Calcasieu. August and September presuppression flights also indicated severe southern pine beetle outbreaks in Allen and Natchitoches Parishes.

In Mississippi, southern pine beetle infestations continued to increase in the northeastern and southeastern portions of the State. Southern pine beetle activity reached outbreak status for the first time in the south-central portion of the State on the Bienville National Forest.

In Alabama, southern pine beetle activity was at a low level. Only eight counties reported southern pine beetle outbreaks compared to 29 counties in 1975.

In South Carolina, southern pine beetle infestations decreased to an endemic level. The only outbreak was on the Edgefield District of the Sumter National Forest.

Southern pine beetle activity in Kentucky was less than was anticipated for the summer months. Previously infested counties showed no obvious spot proliferation. Salvage operations on State lands were limited to the Kentucky Ridge State Forest. Other localized areas of high southern pine beetle infestation were on the Daniel Boone National Forest and Cumberland Gap National Historical Park.

Overall, southern pine beetle activity in North Carolina declined, but losses occurred in the central Piedmont and in several mountain counties. The Tusquitee Ranger District on the Nantahala National Forest continued to have high beetle activity. Infestation declined in the southern part of the Grandfather Ranger District, Pisgah National Forest, but increased on the northern part of the District. Infestations con-

Figure 5.–Winding southern pine beetle larval galleries in a dying loblolly pine in Louisiana.

tinued at about the same level on the Uwarrhie National Forest.

In Florida, the only previous southern pine beetle activity was observed on Eglin Air Force Base in Walton County. In 1976, southern pine beetle activity had increased and spread onto State lands adjoining Holmes County, and in late 1976, eight southern pine beetle spots were detected on the Apalachicola National Forest in Liberty County.

In Virginia, southern pine beetle activity declined over most of the State. Very little activity was detected in the Coastal Plain and Piedmont Regions. A few scattered spots were detected in areas that were considered to have moderate activity last year. Most of the activity was concentrated in the southwestern mountain counties and on the James River Ranger District of the George Washington National Forest.

In the Coastal Plain and Piedmont Regions of Georgia, southern pine beetle activity declined. Infestations were, however, detected in Glynn and Camden Counties for the first time. Continued beetle activity also occurred in the central and northern portions of the State. These areas of southern pine beetle activity were predominantly light and scattered; however, several severe localized infestations also occurred on the Chattanooga-Chickamauga National Military Park.

In the eastern mountains of Tennessee, especially on the Tellico, Nolichucky, and Unaka Districts of the Cherokee National Forest, southern pine beetle activity continued. Numerous outbreaks were also found in the Norris Reservoir area and around the Cumberland Gap.

Engraver beetles, *Ips* spp. Ips engraver beetles remained at low levels throughout most of the Southeastern Area. Scattered Ips infestations were reported in Florida, Virginia, Mississippi, Arkansas, and Oklahoma. In Mississippi, and in particular, Kemper, Jasper, and Newton Counties, Ips spot sizes averaged 30-40 trees or more.

Pine sawflies, *Neodiprion taedae linearis* Ross and *Neodiprion excitans* Rohw. The loblolly pine sawfly (*N. taedae linearis*) continued to defoliate pines throughout the State of Arkansas. Moderate to heavy defoliation occurred over an estimated 30,000 acres of pine forests in Perry, Pulaski, and Sabine Counties.

Scattered infestations of this sawfly and the blackheaded pine sawfly, (*N. excitans*) occurred over 32,000 acres near Columbus, Miss., in Lowndes County. Light to moderate defoliation by these insects had been occurring in this area for the last 7 to 8 years.

In Louisiana, the loblolly sawfly defoliated 57,600 acres. The defoliation was relatively light and restricted to the upper 25 percent of the crown.

Forest tent caterpillar, *Malacosoma disstria* Hbn. Forest tent caterpillar infestations in South Carolina collapsed; however, in western Kentucky, approximately 200 acres were defoliated. This insect also defoliated over 9,160 and 300,000 acres of water tupelo in Alabama and Louisiana, respectively. Both States have a history of forest tent caterpillar defoliations.

Fall cankerworm, *Alsophila pometaria* (Harr.). In northern Georgia, there were four major areas of defoliation on the Chattahoochee National Forest totaling approximately 24,100 acres. This was a several-thousand-acre increase from that reported in 1975. Defoliation was heavy in two of the areas and medium in the other two.

There were approximately 26,000 acres of cankerworm defoliation in southern North Carolina. One large area of 22,000 acres having moderate to heavy defoliation occurred from the Coweeta watershed to the North Carolina-Georgia border. Several smaller areas of medium to light defoliation occurred north of the larger infestation.

In Virginia, little defoliation was noticeable in areas of past activity in the Bull Run Mountains and Shenandoah National Park.

Balsam woolly aphid, *Adelges piceae* (Ratz.). The balsam woolly aphid continued to spread and kill Fraser fir in the southern Appalachian Mountains. Suppression activities were conducted in designated protection areas on Roan Mountain to control the aphid. Mount Rogers, in Virginia, is the only native Fraser fir stand uninfested by the balsam woolly aphid.

Oak sawfly, *Caliroa lineata* MacGill. The primary hosts of this insect are pin, white, and various red oaks. The slug-like larva skeletcnizes the lower surface of the leaves, causing them to turn brown. In Virginia, infestations expanded to include more than 1 million acres. Some branch mortality occurred in areas that had been heavily defoliated for 4 consecutive years. In the eastern and south-central portions of Kentucky, scattered defoliation occurred on about 2,300,000 acres; this was about the same level as last year. The oak sawfly, reported for the first time in North Carolina, defoliated 9,000 acres in three counties.

White-marked tussock moth, *Hemerocampa leucostigma* (J.E. Smith). This insect occurred on the southwest side of Brodwell Bay in Florida. Approximately 1 square mile of native Ti-Ti (*Clistonia monophylla* Britt.) trees were heavily defoliated. Less severe defoliation also radiated out over a total distance of 4 square miles.

Walkingstick, *Diapheromera femorata* (Say). Walkingsticks defoliated hardwoods on the Ouachita National Forest in Arkansas. Defoliation also occurred throughout the State, with Howard County reporting the heaviest damage. In Oklahoma, 200 acres of hardwoods were defoliated by the walkingstick, but the population seemed to be decreasing.

Nantucket pine tip moth, *Rhyacionia frustrana* (Coms.). Nantucket pine tip moth damage to loblolly pines at the Stuart Orchard, La., was 19 percent in untreated areas. Guthion^{R}-treated loblolly pines had 3 percent damage.

Shoot damage caused by tip moth at the Ouachita Orchard, Ark., was 1 percent on Guthion-treated trees and 2 percent of Di-Syston^{R}-formulation treated trees compared to 8 percent on untreated trees.

Pine seed bugs, *Leptoglossus corculus* (Say), *Tetyra bipunctuata* (H.S.). On the Beech Creek Seed Orchard in Murphy, N.C., only 28.1 percent of the initial Virginia pine flower crop was harvested as mature cones. Of the cones harvested, 7.2 percent of the seed had identifiable seed bug damage.

Radiographs of white pine seed lots indicated identifiable seed bug losses at 2.3 percent. Identifiable seed bug damage on loblolly pine at the Francis Marion Orchard, Monck's Corner, S.C., accounted for 12 percent of the seed losses.

Coneworms, *Dioryctria* spp. The Ouachita Seed Orchard, Ark., had only 1.7 percent of the second-year shortleaf cone crop destroyed by *Dioryctria* spp. on the trees treated with Guthion^{R}. The Erambert Orchard, Miss., reported second-year slash pine cone losses due to *Dioryctria* spp. (fig. 6) was less than 1 percent; consequently, treatment was not needed.

Other insects. Sawflies, *Neodiprion excitans* Rohw., infested up to 60 percent of the shortleaf and loblolly pines on the Francis Marion Seed Orchard in South Carolina. Black cherry trees at the Beech Creek Seed Orchard were defoliated by grasshoppers and the web-spinning sawfly, *Neurotoma fasciata* (Nort.). White pine cone beetle, *Conopthorus coniperda* (Schwar.), destroyed 78 percent of the white pine cone crop on the Beech Creek Seed Orchard. A control treatment was not available. About 1 percent of the trees at the

Figure 6.–Coneworm feeding in slash pine cone.

Ocala pine Seed Orchard, Ocala, Fla., were infested with tip moths, *Rhyacionia* spp.

Status of Diseases

Fusiform rust, *Cronartium fusiforme* (A&K) Hedg. & Hunt. Third year observations in central Louisiana slash pine plantations 3 to 17 years old revealed that 53 percent of the trees were infected with fusiform rust. Of these trees, 36 percent had stem galls and 17 percent had branch galls within 15 inches of the stem. Eight percent of the trees had died from rust and 5 percent had died from other causes.

Data collected in 1976 shows that the incidence of fusiform rust increased in loblolly pine sample plots in South Carolina. An increased incidence was also observed in plantations ranging in age from 3 to 13 years, and new infestations were up from between 1 and 9 percent over the previous year.

Annosus root rot, *Fomitopsis annosa* (Fr.) Karst. Annosus root rot continued to cause damage in localized areas. First-thinned loblolly pine plantations near Charleston, S.C., had approximately 25 percent mortality due to annosus root rot. The pine plantations were thinned 3 to 4 years previously with no protective chemical stump treatments applied. The affected plantations were on former agriculture sites with deep sandy topsoils and low water tables. Such sites are a high hazard for annosus root rot.

Oak wilt, *Ceratocystis fagacearum* (Bretz.) Hunt. This disease remained at relatively low levels in eight Southern States. Survey results in North Carolina, however, showed an increase in oak wilt incidence over 1975. In addition, scattered infections were again observed in and around Kershaw County, S.C., and in oak shade trees near Kinston in eastern North Carolina. No oak wilt control measures were applied in the South during 1976.

White pine blister rust, *Cronartium ribicola* Fisch and Waldh. White pine blister rust caused localized severe damage to eastern white pine plantations and Christmas tree plantings in the high rust-hazard mountainous areas of western North Carolina and Virginia. Blister rust impact plots were evaluated for the third time since they were established in 1970. Results showed relatively little increase in either blister rust incidence or mortality on the George Washington and Jefferson National Forests and Shenandoah National Park in Virginia. A few exceptions occurred in localized disease "hot spots" where 50 percent cumulative infection and over 25 percent cumulative mortality have been recorded during the past 6 years. Ribes eradication control work was carried out on some State and private lands in North Carolina and Virginia.

Pitch canker, *Fusarium moniliforme* var. *subglutinans* Wr. & Remk. An evaluation of pitch canker incidence, severity, and impact was made in Florida slash pine plantations and seed orchards. The disease was found in all 67 Florida counties. Twenty-two of the 25 slash pine seed orchards were infected with pitch canker. Statewide, disease incidence was 2 percent in trees 5 to 10 years, 5 percent in trees 11 to 16 years, 13 percent in trees 17 to 22 years, and 25 percent in trees 23 to 28 years. Incidence was highest and disease most widespread on flat, sandy, wet, and fertilized sites.

Pitch canker disease was identified on shortleaf pine at two locations in eastern Tennessee; the Tennessee Valley Authority facility at Oak Ridge, and Holston Army Ammunition Plant. A *Fusarium* sp. was isolated from the infected trees. Since 1973, approximately 73 acres of shortleaf have had to be harvested because of advancing decline and mortality. At Holston Ammunition Plant, *F. moniliforme* var. *subglutinans* was isolated from shortleaf pines.

Nursery diseases. Cylindrocladium root rot, *Cylindrocladium* spp., caused severe localized damage in 1-0 black walnut and yellow poplar seedlings beds (fig. 7). The disease was detected in 18 nurseries in 9 southern States. In addition, a cylindrocladium damping-off disease problem was detected on Caribbean pine containerized seedlings in a Puerto Rican nursery. Cylindro-

Figure 7.—Cylindrocladium root rot damage in 1-0 walnut seedlings.

cladium root rot disease was also detected in experimental yellow poplar seedling microplots at the Forest Sciences Laboratory, Athens, Ga., and in experimental containerized water oak seedlings at a nursery near Summerville, N.C.

Black walnut and yellow poplar outplantings continued to show variable results after 5 and 4 years, respectively. Mortality was about 75 percent on black walnut with more than 10 percent cylindrocladium tap root rot at time of planting. These seedlings had over 75 percent survival and approximately the same growth rate as noninfected check trees.

Black root rot, caused by the fungi, *Sclerotium bataticola* Taub. (Davis) and *Fusarium* sp., caused localized severe damage to loblolly, slash, and sand pines in southern nurseries. The disease caused highly significant and serious economic damage to 1-0 slash and loblolly pine seedlings at a nursery in Florida during this growing season. About one-third of approximately 30 million seedlings were lost to black root rot and associated soil pathogenic fungi, such as *Pythium* spp. and *Rhizoctonia* spp. A similar root rot problem was observed on slash, loblolly,.and sand pine at a nursery near Albany, Ga. With a few exceptions, incidence of fusiform rust, caused by *Cronartium fusiforme*, was low (2 to 3 percent) in southern nurseries during the 1975 growing season. Ferbam^{R} protective sprays continued to provide good results.

Diseases appeared to be at a low level in Gulf States nurseries. Phytophthora root rot was the probable disease affecting approximately 10,000 walnut seedlings at the Baucum State Forest Nursery near Little Rock, Ark. MC-33^{R} (methyl bromide, 67 percent; and chloropicrin, 33 percent) and Truban^{R} were applied to control the problem.

Mycorrhizae. Mycorrizae outplanting study results showed a highly significant increase in both survival and growth on several southern pine species artifically inoculated with the mycorrhizal fungus, *Pisolithus tinctorium* (Pers.) Coker and Couch, after 2 years in the field. Artificially inoculated pine species, such as sand pine and eastern white pine showed over 400-percent increase in growth as compared with naturally inoculated seedlings. Artificially inoculated loblolly, slash, and Virginia pines showed over 50-percent increases in growth response in North Carolina and Florida. Similar positive results were obtained on a variety of reforestation sites, and in pine species following artificial nursery seedbed inoculations with *P. tinctorius* in the United States during the past 2 years.

Atmospheric pollutants. Several incidents of suspected air pollution injury were evaluated. In one instance in North Carolina, the causal toxin could not be identified, but appeared to have been released intermittently over a period of 1 year. Other incidents were found to be caused by localized emissions in urban areas.

An evaluation was made of the forest vegetation in the vicinity of bromine extraction plants in Arkansas. Some foliage symptoms observed on loblolly pine may have been caused by air pollution, but no conclusions could be made because of a lack of supporting information on pollutant types and concentrations, character, and duration of fumigations and sensitivity of the trees.

Other diseases. Oak decline and mortality occurred in Mississippi, Oklahoma, Texas, Louisiana, and Arkansas. Mortality of post oak, southern red, and willow oak was less than in previous years. The cause of this oak decline and mortality has not been determined.

Live oak decline. In Texas, live oak decline continued to be a problem in some areas. A *Cephalosporium* sp. was identified as one contributing factor of decline, but the cause appeared to be a combination of factors.

Seed tree decline. Decline and some mortality to loblolly seed trees occurred in some loblolly seed tree cuts in southeast Louisiana. *Phytophthora cinnamoni* Rands. and *Pythium* spp. were isolated from feeder roots and soil samples in affected stands.

Disease impact in cottonwood plantations. The impact of diseases in cottonwood plantations in the Southern United States was light. Results of an evaluation showed

that incidence of cottonwood canker, *Fusarium solani* (Mart.) App. & Wr. em. Snyd. & Hans., was very low and that there was no serious defoliation caused by foilage diseases. Tree mortality was caused primarily by suppression and wind damage. Up to 20 percent of the planting spaces were unoccupied in most age classes. This was possibly due to canker-caused mortality during the first growing season.

EASTERN REGION (R-9)[7] AND NORTHEASTERN AREA

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Conditions in Brief

The spruce budworm caused the most damage in the Northeastern Area again in 1976. Over 6.2 million acres were affected. Maine suffered defoliation on 4 million acres, Minnesota 1.2 million acres, and Michigan 815,000 acres. Other States having heavy damage were Wisconsin and New Hampshire. In Maine, about 3.5 million acres of spruce-fir were aerially treated for foliage protection. The 854,000 acres defoliated by the gypsy moth represented a dramatic increase over 1975. Pennsylvania accounted for almost all of the increase. The forest tent caterpillar remained at high levels in Michigan with about 333,000 acres being defoliated. Populations of the caterpillar remained low in Minnesota, but appeared to be increasing in nearby Canada. The saddled prominent was making a resurgence after several years of no reports. Maine sustained most of the damage, with over one-half million acres of northern hardwoods defoliated. Populations of the fall cankerworm remained high in 1976. Pennsylvania reported over 700,000 acres of defoliation.

Dutch elm disease continued to cause mortality in the Lake States. Scleroderris continued to cause concern in New York, where it was causing mortality in all tree sizes. In the Lake States, this disease has traditionally been a pest of smaller plantation trees. Researchers are investigating the situation to determine why the fungus behaves differently in New York. Maple decline increased drastically in the Lake States, Vermont, New York, and New Hampshire. Dipolodia tip blight was especially severe on red and jack pine in Wisconsin during the summer. This disease could be a serious problem to some of our pine species in the future.

Status of Insects

Spruce budworm, *Choristoneura fumiferana* (Clem.). This insect was the most serious conifer defoliator in the Northeastern Area. In the East, budworm populations appeared to be on the rise. New Hampshire reported 100,000 acres of visible defoliation in the northeastern portion of the State. Surveys in New York revealed light infestations on all 250,000 acres of spruce-fir type. Vermont also had increasing populations, with 5,000 acres having light to moderate defoliation. Maine was the only State where a decrease was noted. Approximately 4 million acres of spruce-fir type vegetation suffered moderate to heavy defoliation, compared to 7 million acres in 1975.

The budworm was also a major problem in the Lake States. Infestations in northeastern Minnesota drastically increased. Over 1.2 million acres were defoliated, with all but 80,000 acres listed as severe. In Upper Michigan, nearly all of the spruce-fir type was infested. Defoliation was recorded on 815,000 acres, 90 percent of which was rated in the heavy defoliation category. In lower Michigan, populations declined because most of the balsam fir host type had already been killed or was declining. Wisconsin reported an increase in defoliation in the northeastern portion of the State; 104,000 acres were defoliated in 1976. About 70,000 acres were classified as having moderate to severe defoliation.

During 1976, a number of pilot control projects, testing six insecticides against the budworm, were conducted by the Forest Service, U.S. Department of Agriculture, and the University of Maine.

In June 1976, 3.5 million acres of spruce-fir in Maine's Aroostook, Piscataquis, Penobscot, and Washington Counties were aerially treated for foliage protection against the budworm.

Jack pine budworm, *Choristoneura pinus* Free. Jack pine budworm populations in Michigan continued to decline from the outbreak high of 500,000 acres in 1974. Only 5,000 acres of light defoliation were recorded in Presque Isle County. Populations collapsed in Wisconsin during the summer, and about 11,500 acres in central and northwest Minnesota were reported as moderately defoliated. However, egg surveys later in the season indicated a population collapse.

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[7] Includes forests in Connecticut, Delaware, Illinois, Indiana, Iowa, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, Maine, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin.

Arborvitae leafminer, *Argyresthia thuiella* (Pack.). High populations of this leafminer continued throughout most of upper Michigan affecting 150,000 acres. Tree mortality caused by this insect complex averaged about 1 percent. Defoliation was more severe on the edges of a stand, and at least three species of leafminers were involved in the outbreak. The population is expected to decrease in 1977.

Larch casebearer, *Coleophora laricella* (Hbn.). Casebearer infestation was reported in Pennsylvania, New Jersey, and Vermont. In New Jersey and Vermont, the insect is considered a seed orchard problem.

Balsam gall midge, *Dasineura balsamicola* (Lint.). Damage by this midge continued in Wisconsin, Vermont, and New Hampshire. Attempts to control the midge in Vermont with dimethoate and malathion failed. There was 3 percent parasitism by *Tetrastichus marcovitchi* (Cwfd.) in Vermont. Although this is a pest of both plantation and natural stands, it was a major problem in balsam fir Christmas tree plantations.

The introduced pine sawfly, *Diprion similis* (Hart.). This insect continued to pose a problem on the Red Lake Indian Reservation in Minnesota. About 3,600 acres of white pine were affected; half of the damage was in the moderate to severe category. With the exception of Michigan, the larch sawfly caused moderate to severe damage throughout the Lake States. In the East, Maine recorded heavy damage for the third year. Small localized infestations were also reported from Vermont and Pennsylvania.

The European pine sawfly, *Neodiprion sertifer* (Geof.) Populations were low this year, except in Ohio. Several University of Wisconsin entomologists used natural-pheromone-baited traps to capture male European pine sawflies beyond the insect's known northward distribution

Yellow-headed spruce sawfly, *Pikonema alaskensis* (Rohw.). Michigan and Minnesota reported locally severe defoliation on white spruce. Several plantations in Minnesota were treated to prevent defoliation.

Jack pine sawfly, *Neodiprion pratti banksianae* Rohw. This insect caused light to moderate defoliation on 2,000 acres in Michigan.

Gypsy moth, *Lymantria dispar* (L.). Gypsy moth populations have increased substantially since 1975 (table 1). Defoliation exceeded the previous year's by 390,000 acres. Pennsylvania accounted for 82 percent of this increase, much of which occurred in the Pocono Mountains, where infestations had collapsed following severe defoliation in 1973. There was no correlation in the buildup between areas that had been sprayed earlier and those that had not been sprayed. Resurgence of the gypsy moth in the area had not been expected in such a short time. The cooperative suppression programs involved about 45,000 acres in New Jersey, and 5,000 acres in Rhode Island. Both States used carbaryl as the primary insecticide. The Michigan Department of Agriculture, in cooperation with the Animal and Plant Health Inspection Service, USDA, treated 16,330 acres with carbaryl in an attempt to eradicate the gypsy moth in Isabella, Midland, and Montcalm Counties in central Michigan.

Table 1.–Area defoliated by the gypsy moth

State	1975	1976
	(In acres)	
Connecticut	63,411	9,809
Maine	110	0
Massachusetts	17,900	31,720
New Jersey	55,400	45,850
New York	9,275	26,593
Pennsylvania	317,800	732,310
Rhode Island	435	7,540
Vermont	30	750
Total	464,361	854,572

The disparlure-bait trapping program continued in 1976. No male moths were trapped in Missouri. The highest number of moths trapped was 432 male moths in four counties in Michigan.

Gypsy moth parasites were reared and released by Pennsylvania and Wisconsin in 1976. The Pennsylvania releases involved 6 parasite species totaling about 476,000 insects. Wisconsin's releases included *Compsilura concinata* Meig. and *Brachymeria intermedia* Nees; 12,000 parasites were released. Extreme cold weather in Vermont prevented 97 percent of the overwintering gypsy moth egg masses, located 2 feet or more above the ground, from hatching. An estimated 92 percent of the egg masses were located above the 2-foot-height level. However, the cold weather did not prevent populations from dramatically increasing in northern Vermont. New Jersey conducted a gypsy moth impact study in 1976. Evaluations on 808,000 acres which had been defoliated by the gypsy moth for 2 or more consecutive years showed an average mortality rate of 20 percent, with a total loss of 236 million board feet of sawtimber and 234 million cubic feet of pulpwood, and a combined value of $8,357,600. Ninety-four percent of the trees killed were oak.

Fall cankerworm, *Alsophila pometaria* (Harr.). Cankerworm populations reached outbreak proportions again. Infestations were reported in Pennsylvania, New

Jersey, Rhode Island, Maine, New York, Illinois, and Wisconsin. The largest area of defoliation was on 700,000 acres in Pennsylvania. Although no acreage was reported from Wisconsin, pockets of heavy defoliation could be found throughout the southern portion of the State. The community of Elm Grove, Wisc., a Milwaukee suburb, was treated with *Bacillus thuringiensis* to minimize the caterpillar's impact. New Jersey reported 3,500 acres were defoliated. There, the cankerworm was associated with oak leaf rollers. Approximately, 3,500 acres were treated with carbaryl to control cankerworm oak leaf roller populations. All States, except New Jersey, reported unusually high populations of *Calosoma* sp. beetles preying on the cankerworm complex. The linden looper was the predominent species associated with the cankerworm in Pennsylvania.

Forest tent caterpillar, *Malacosoma disstria* Hbn. Although forest tent caterpillar outbreaks in upper Michigan decreased somewhat in 1976, about 133,000 acres were defoliated. About 200,000 acres had been defoliated in the Upper Peninsula in 1975. Elsewhere, Indiana reported 15,000 acres, and Vermont 4,500 acres, defoliated by the caterpillar. Infestations were also reported in Rhode Island, New York, and Maine. Populations in Minnesota remained at low levels; however, a larger population developing in the Province of Manitoba may suggest a problem for Minnesota in the near future.

Oak leaftier complex, *Croesia albicomana* (Clem.), *Archips semiferanus* (Walk.), and other species. This tier-roller complex continued to be a problem in West Virginia, where over 100,000 acres were defoliated. Massachusetts reported 20,000 acres of damage, a considerable increase over the defoliation of 1975. In the Lake States, only Michigan reported damage by *A. semiferanus;* five counties in lower Michigan had moderate to heavy defoliation, while the Upper Peninsula suffered 6,000 acres of damage. Only 1,000 acres of defoliation were detected in Pennsylvania.

Large aspen tortrix, *Choristoneura conflictana* (Walk.). Defoliation by this tortrix was reported in Vermont and Minnesota. The population in Minnesota was on the rise, with 15,000 acres being defoliated in 1976, compared to no detectable damage the year before. The population in Vermont remained high, with 11,500 acres defoliated again in 1976.

Maple leafcutter, *Paraclemensia acerifoliella* (Fitch). In Vermont, the leafcutter defoliated large acreages for the second consecutive year. Thirty-four thousand acres were defoliated in 1976, an increase of 3,000 acres over the previous year. Defoliation also occurred in New Hampshire and Michigan.

Saddled prominent, *Heterocampa guttivitta* (Walk.). This pest appeared to be making a resurgence after several years of no reports. Maine sustained most of the damage, with over a half million acres of beech, birch, sugar maple, and red maple severely defoliated. Michigan reported defoliation on 15,000 acres and Wisconsin on 10,000 acres. Although not always mentioned, the saddled prominent is the dominant species in a complex of hardwood defoliators which usually includes other *Heterocampa* spp., *Symmerista* spp., and *Anisota* spp.

Walnut caterpillar, *Datana integerrima* G. & R. Infestations of this *Datana* caused moderate damage in southeastern Illinois, and heavy damage in southwest Missouri (fig. 8). Excellent control was achieved in Illinois with diazinon, malathion, acephate, and *Bacillus thuringiensis.*

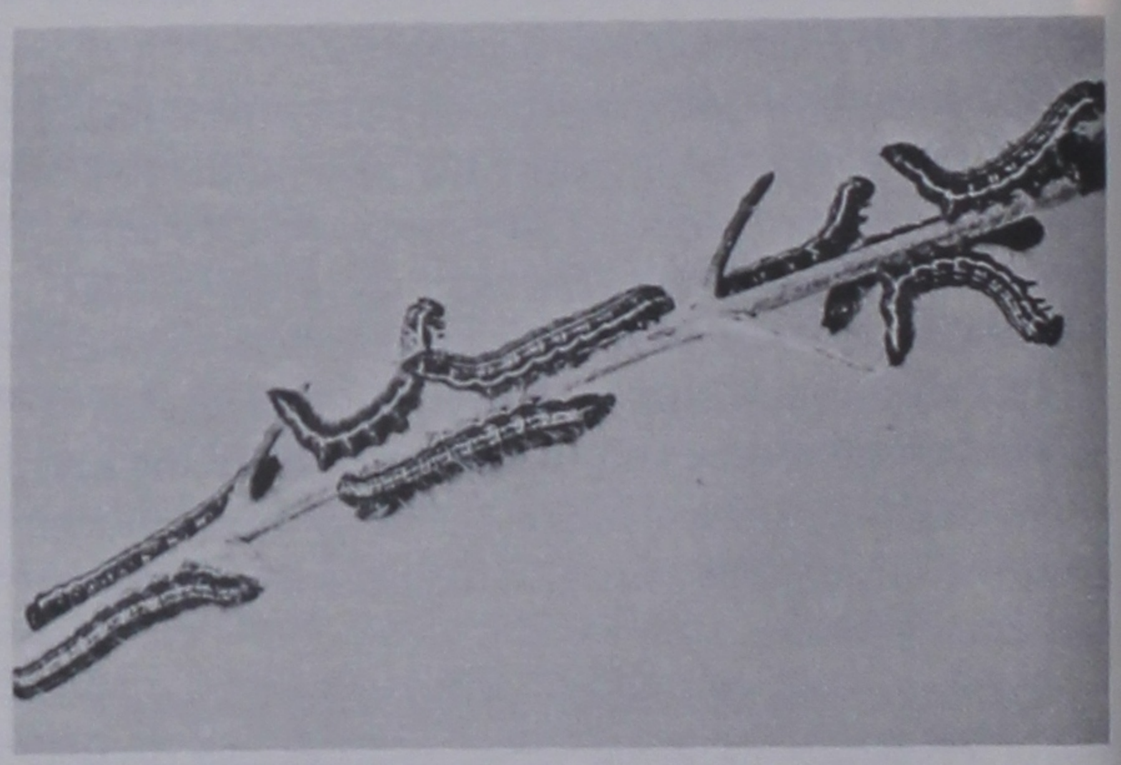

Figure 8.—Larval stage of the walnut caterpillar.

Oak sawfly, *Caliroa quercuscoccineae* (Dyar). The unusual occurrence of this slug-like sawfly caused about 100,000 acres of defoliation on oak in West Virginia during 1976 (fig. 9). The sawfly has two generations per year. The first generation occurs in early July, and the second in late August or early September.

Fall webworm, *Hyphantria cunea* (Drury). Fall webworm nests were conspicuous over much of Pennsylvania, West Virginia, Ohio, Missouri, Indiana, New York, and New England. Although the populations have not yet reached the damaging levels of the early 1970's, heavy defoliation occurred in Massachusetts, West Virginia, and Missouri.

Birch leafminer, *Fenusa pusilla* (Lep.). Damage by this miner was statewide in Rhode Island and Vermont, and it continued to be one of the major shade tree insects. Heavy infestations were also noted at the local

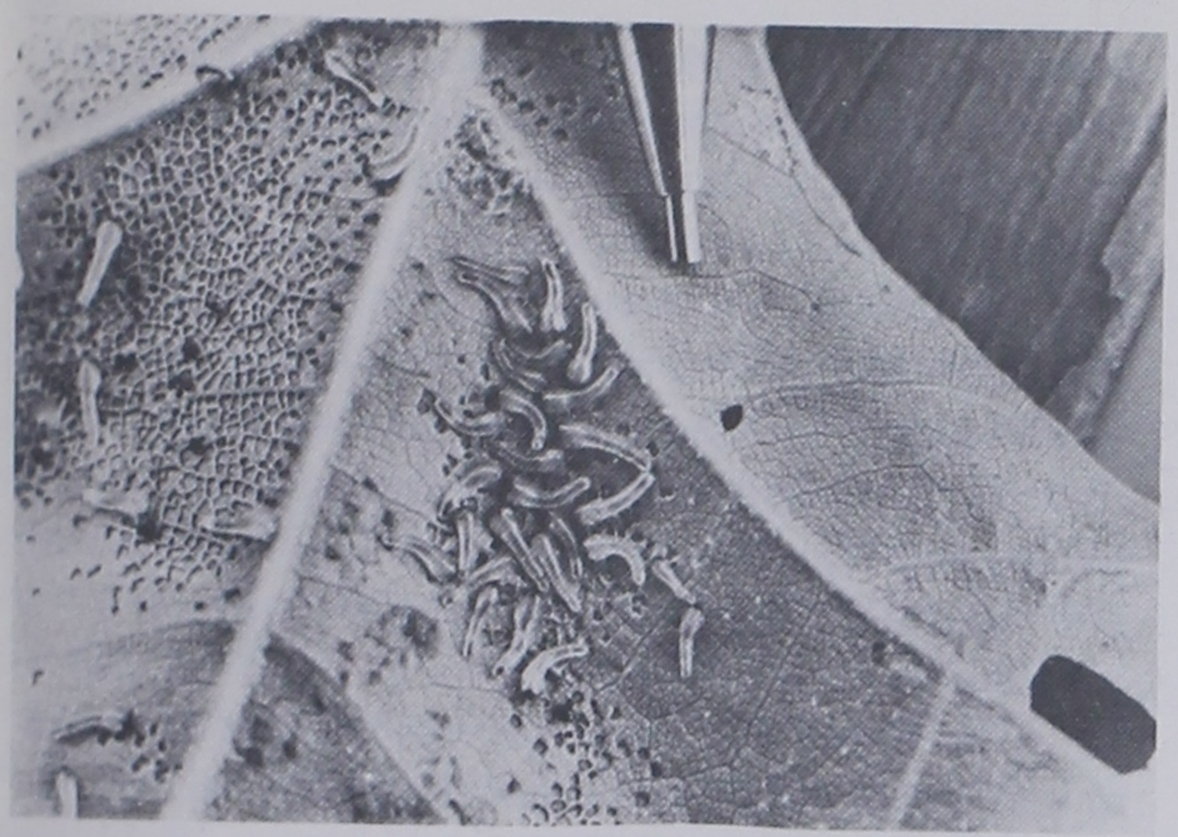

Figure 9.–The slug-like larvae of the oak sawfly, *Caliroa quercuscoccineae* (Dyar), skeletonize the underside of oak leaves, causing them to have a brownish appearance.

level in Maine, upper Michigan, and northern Wisconsin.

Spittlebugs, *Aphrophora saratogensis* (Fitch) and *A. parallela* (Say). Damage caused by the Saratoga spittlebug has increased, especially in Wisconsin and Michigan. In Michigan, some plantation damage was so severe that control measures could not be justified.

Wisconsin successfully treated severe damage on about 150 acres. An additional 500 acres were known to have heavy populations and may require treatment in 1977. The pine spittlebug caused some mortality and flagging on an 85-acre Christmas tree plantation in Pennsylvania. Heavy infestations of the pine spittlebug also occurred on white pine and balsam fir in southern New Hampshire. Indiana reported that the pine spittlebug was a statewide Christmas tree problem.

Red pine scale, *Matsucoccus resinosae* Bean & Godw. This scale was established in New Jersey, New York, and Connecticut. Guidelines for transportation of red pine and/or quarantine measures are in force in Connecticut and New Jersey. New York does not have a quarantine on the transportation of infested material.

Nantucket pine tip moth, *Rhyacionia frustrana* (Coms.). This tip moth caused considerable damage at Lakin Nursery and in Scots pine plantations throughout West Virginia. Populations also remained high on Cape Cod, Mass., where many pitch pine stands were being severely damaged.

Black walnut shoot moth, *Acrobasis demotella* Grt. and the Pecan leaf casebearer, *A. juglandis* (LeB.). In Wisconsin, high populations of *A. juglandis,* in a number of 5- to 10-year old plantations, collapsed before going into overwintering hibernacula. Overwintering hibernacula in one plantation failed to emerge in the spring. No reasons were given for the collapse of these populations. Both *Acrobasis* spp. damaged Indiana plantations over 3 years old.

Pine root tip weevil, *Hylobius rhizophagus* Buch. Flagging and tree mortality continued in Scots pine areas in lower Michigan. A 10-county survey showed 75 percent of the trees had some degree of flagging, and an average of 15 percent mortality.

Bark beetles, *Ips pini* (Say) and other species. An anticipated increase in bark beetle outbreaks in Michigan and Wisconsin was expected this summer because of abnormally dry conditions, but little occurred. Some tree mortality occurred in overstocked stands, windbreaks, and in areas of active timber sales. West Virginia reported many inquiries about *Ips* and the southern pine beetle.

Other insects. The locust leafminer, *Xenochalepus dorsalis* (Thun.) again caused heavy damage on black locust trees in Ohio, West Virginia, and Pennsylvania. The Asiatic oak weevil, *Cyrtepistomus castanus* (Roelf.), caused problems in West Virginia and Missouri; about 2,000 acres were affected in West Virginia. An outbreak of the orangestriped oakworm, *Anisota senatoria* (J.E. Smith), occurred in New Jersey during September where heavy defoliation was recorded in portions of four counties. Red pine plantations in lower Michigan sustained mortality from the pine root collar weevil, *Hylobius radicis* Buch.

Status of Diseases

Dutch elm disease, *Ceratocystis ulmi* (Buism.) C. Mor. This disease continued to increase in upper Michigan, Wisconsin, and Minnesota. This year, 25,000 elm trees were lost to Dutch elm disease in the Minneapolis metropolitan area. A seven-county area, encompassing the Twin Cities, has 4 million elm shade trees. Other States noting losses were Iowa, Vermont, Indiana, and West Virginia. Lignasan BLP gave an additional option for the control of this disease in 1976. Lignasan is a more soluble form of benomyl, and is registered for tree injection by licensed arborists (fig. 10).

Oak wilt, *Ceratocystis fagacearum* Hunt. Oak wilt was endemic in Michigan, Missouri, Iowa, Indiana, Illinois, and West Virginia. It is a serious pest in Wisconsin and Minnesota. Minnesota reported that the impact of oak wilt on woodlots was greater than that from Dutch elm disease. An aerial survey in Iowa showed that there was only 0.9 percent incidence of oak wilt over 8,800 acres surveyed.

Lophodermium needle cast, *Lophodermium pinastri* (Schrad. ex Hook.) Chev. Only Vermont and Indiana reported damage from *L. pinastri.* Control was needed

Figure 10.–Elm tree being injected with Lignasan BLP to control Dutch elm disease.

in several Christmas tree plantations in Vermont.

Pine needle rust, *Coleosporium* spp. Needle rust was observed in Michigan and Indiana. Wet weather during August, 1975, was responsible for the larger number of reports of this disease in young red pine plantations in southern Michigan this spring. This disease caused serious damage to trees suppressed by competing vegetation. Control of weeds and competing vegetation allowed trees to dry quickly and reduced the incidence of infection.

Anthracnose, species of *Gnomonia, Gloeosporium, Marssonina,* and others. The incidence of anthracnose was high in Iowa, Michigan, Massachusetts, Vermont, Minnesota, New York, West Virginia, and Pennsylvania. Anthracnose of chestnut and white oak was especially severe throughout Pennsylvania. Widespread occurrence of anthracnose on ash was also observed. In Michigan, it was common on sycamore, oak, and maple in the southern portion of the State.

Aspen shoot blight, *Venturia populina* (Vuill.) Fabric. Aspen shoot blight continued to be a problem on aspen regeneration, causing top kill and dieback of the current year's shoots. Damage was evident throughout the Lake States.

Scleroderris canker, *Gremmeniella abietina* (Largerb.) Morlet (= *Scleroderris lagerbergii* (Gremmen)). In upper Michigan, the major impact of this disease was in Schoolcraft and Luce Counties, where it has prohibited reforestation of a 25,000-acre area. Test plantings of resistant varieties of Scots pine are planned.

The disease was present in 93 out of 128 plantations examined in New York; this compares with 77 plantations found infected in 1973. In New York, the disease also killed trees of all sizes; whereas, in the Lake States, it was a problem of smaller plantation trees. Researchers are investigating the situation to determine why the fungus behaves differently in New York.

Red pine shoot blight, *Sirococcus strobilinus* (Pruess). This blight continued to damage shoots and kill red pine reproduction in northeastern Wisconsin. The removal of overstory trees was effective in reducing the severity and incidence of overstory infection. This silvicultural technique enables land managers to keep disease associated losses to a minimum.

Diplodia tip blight, *Diplodia pinea* (Desm.) Kickx. This disease killed red, jack, Scots, Austrian, and ponderosa pines. Losses were particularly severe this summer on red and jack pine in central Wisconsin (fig. 11). Drought and sandy soils appeared to predispose trees to diplodia tip blight infection. Pathologists in Wisconsin are concerned that this blight could become a serious problem in the future. Vermont and Minnesota also reported evidence of the disease. Severe blighting and killing of Austrian pine was diagnosed in several locations in Ohio this past summer. West Virginia reported severe damage to one plantation.

Beech bark disease, a combination of beech scales and *Nectria coccinea* var. *faginata* Loh., Wats., and Ay. Populations of one of the beech scales, *Cryptococcus fagi* (Baer), were down in most of the Northeast. However, about 20 percent of the large beech in New Hampshire has been killed by this disease since 1959. The disease continued to spread westward in New York. Heavy salvage cuts were made on State forests in south-central New York. The known distribution remained the same in Pennsylvania, and mortality occurred throughout the area where the insect/disease complex was found.

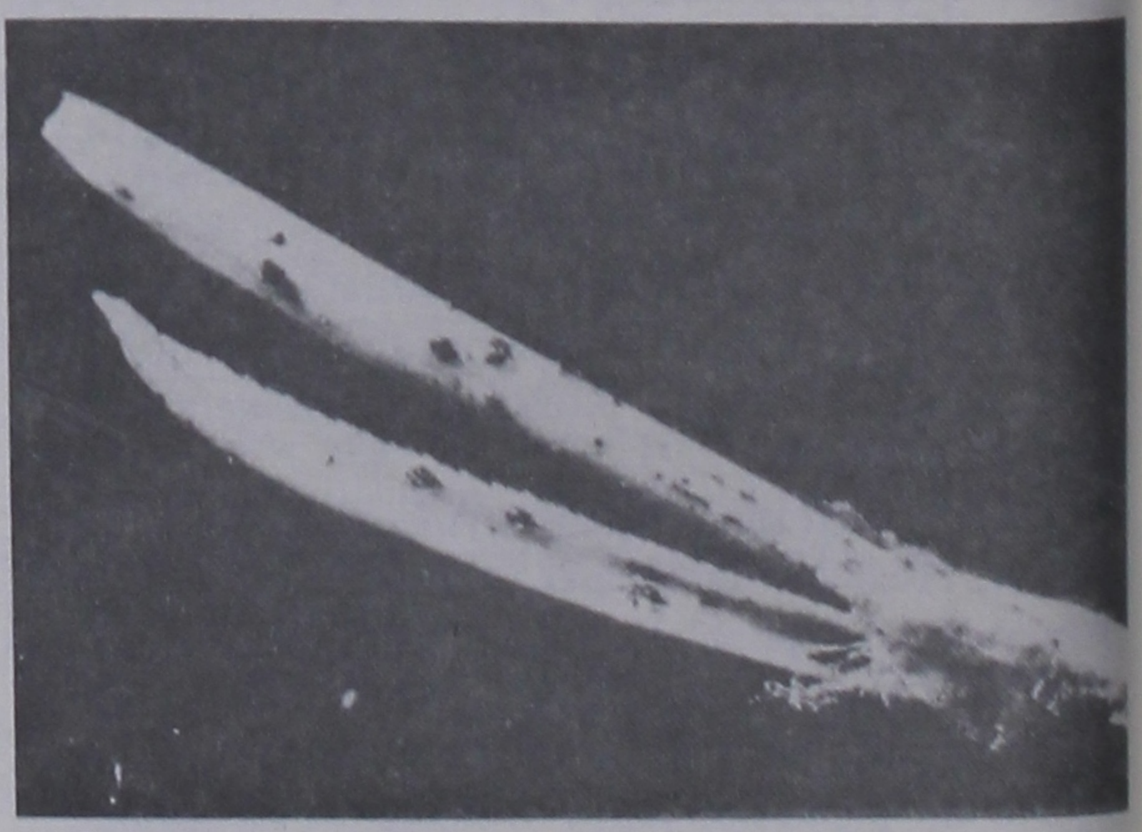

Figure 11.–Black fruiting bodies of *Diplodia pinea* on red pine.

Sweetfern rust, *Cronartium comptoniae* Arth. This disease continued to be a serious pest in jack pine stands in the Lake States. One stand in Minnesota had 80 percent of the stems infested.

Cankers, species of *Nectria, Fusarium, Diaporthe,* and *Hypoxylon.* During a cooperative survey by Michigan and the Forest Service, USDA's specific hazard zones, where the disease had a significant impact on the management of yellow birch, were identified. In most cases, the severity of infection increased near the Great Lakes. The "Lake effect" could have a significant impact on the management of northern hardwoods in the Upper Peninsula. In New England, yellow birch canker and shoot blight, caused by *Diaporthe alleghaniensis* R.H. Arn. and *Gnomonia setacea* (Pers. ex Fr.) Ces. & de Not., posed problems in regeneration in old logging areas. Indiana reported several canker problems in plantation hardwoods. Fusarium cankering symptoms were found on black walnut in northern Indiana. The canker caused dieback and extended from the root collar to some 2 feet above the ground. Hypoxylon canker of aspen continued to kill about 10 percent of the aspen stems in the Lake States each year (fig. 12).

White pine root decline, *Verticicladiella procera* (Kend.). The incidence of this disease appeared to be increasing in Pennsylvania, Ohio, and West Virginia. The disease's presence in Pennsylvania had been suspected since 1968, but the first culture confirmation was obtained in 1976. Twenty percent mortality of the trees in a plantation was common where the disease occurred. Both West Virginia and Ohio had heavy losses due to the root decline.

Shoestring root rot, *Armillariella mellea* (Vahl. ex Fr.) Karst. Reports of armillariella root rot causing pine mortality were more common and severe in 1976, principally due to drought conditions which existed in portions of the Northeastern Area. Wisconsin reported mortality in red pine, jack pine, and Scots pine stands. In some areas, mortality was as high as 25 percent. Several reports were received from Minnesota where this disease was killing conifers planted in cutover hardwood areas. The disease also caused spruce mortality in Massachusetts and Vermont.

Nursery diseases. A new root rot of pine species (cause unknown) was found in Wisconsin and Minnesota. Root rots, caused by species of *Phytophthora, Fusarium,*

Figure 12.–Damage in aspen stand caused by hypoxylon canker.

Pythium, Phomopsis, and *Cylindrocladium* killed 10 percent of the black walnut seedlings at the Vallonia Nursery in Indiana. The root rot possibly resulted from excessive water, which was caused by heavy watering to prevent spring frost damage.

Oak mortality, cause(s) unknown. Oak mortality occurred in Missouri, Illinois, Indiana, Ohio, Pennsylvania, West Virginia, and New Jersey. Some variations did occur in the order of symptoms, but generally, the trees followed this basic sequence: failure to leaf out in the spring, or if so, the leaves expanded only a fraction of their normal size; the tree died in late summer; the leaves remained on the dead trees, contrary to the premature leaf fall in oak wilt trees. Studies of this situation were underway in Illinois, Pennsylvania, and New Jersey.

Butternut decline, cause(s) unknown. Butternut decline was first observed in Wisconsin in 1967, but was recently found in Michigan, Minnesota, and Iowa. Preliminary findings indicated that a fungus may be involved in the symptomatic cankering. Tests at the University of Wisconsin showed that the isolated fungus incited cankers on black walnut seedlings in the greenhouse. A nationwide survey was underway to determine disease incidence and distribution.

Maple decline, cause(s) unknown. The incidence of maple decline increased drastically in 1976. Most of the reports involved urban areas or roadside trees. However, several States reported it in forested situations. Stress factors such as drought and soil compaction undoubtedly played an important role in the upsurge of maple decline. States reporting maple decline were Michigan, Wisconsin, Vermont, New Hampshire, and Indiana.

Weather related damage. A major ice storm in early March caused widespread damage to vegetation across southern Wisconsin and southern Michigan. High winds, following ice accumulations of up to 5 inches, resulted in total destruction of trees or severe breakage of branches. The storm's long range effects on the incidence of decay and other pest problems will not be known for many years.

Late spring frosts damaged plant growth in Missouri, Michigan, and Pennsylvania. A May snow storm in Vermont resulted in extensive leaf, branch, and top damage over thousands of acres. The damage was most extensive at higher elevations.

The severe drought which occurred over much of Wisconsin and Minnesota had an adverse affect on many trees. Minnesota reported that a large number of trees lost their leaves in August. Birch and maples were the first species to lose leaves. Wisconsin reported increased losses from two-lined chestnut borer and bark beetle activity as a result of the drought.

Mycorrhizae. Surveys of mycorrhizae in nurseries in Wisconsin, Minnesota, Michigan, Iowa, Illinois, and Missouri showed that red pine has poor ectomycorrhizal development; Scotts pine, medium development; and white pine had the best development. Based on a limited evaluation, yellow birch had excellent development. A survey of mycorrhizal development in black walnut seedlings in 18 nurseries in the Eastern United States, showed endomycorrhizae present in all of the seedlings.

Methods for increasing mycorrhizal development are being developed and tested. Results from pilot projects involving inoculation of seedbeds with mycorrhizae were to be available in 1977.

ALASKA REGION (R-10)

by

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Conditions in Brief

Spruce beetle activity in the Cook Inlet basin decreased substantially from that reported in 1975. Only scattered spots of activity occurred within the 167,000 acres of active infestation reported in 1975. With the exception of a localized outbreak in the Resurrection Creek drainage, spruce beetle populations on the Kenai Peninsula remained low.

The eastern larch beetle continued to cause scattered tamarack mortality on about 350,000 acres, with increased activity in the northeastern portion of the infestation. Spear-marked black moth populations in interior Alaska collapsed. Only a few scattered spots of light paper birch defoliation in the vicinity of Fairbanks were detected. Residents of the Tanana River Valley saw increased browning on tamarack due to spring defoliation by a budmoth. Cedars in southeast Alaska continued to die due to a cedar bark beetle. Localized flareups of leaf rollers on paper birch in south-central Alaska caused considerable public concern. Hemlock sawfly and western black-headed budworm populations were endemic in southeast Alaska.

Tree diseases of concern in southeast Alaska included hemlock dwarf mistletoe, sirococcus shoot blight, spruce

needle rust, and a root disease. A spruce needle and twig necrosis, affecting white spruce, was widespread in the Anchorage area and on the northern Kenai Peninsula. Birch and aspen injury was detected on permanent timber inventory plots in interior Alaska.

Status of Insects

Spruce beetle, *Dendroctonus rufipennis* (Kby.). Spruce beetle activity on the west side of Cook Inlet had decreased substantially. Only scattered infestations remained in the 167,000 acres of active infestation reported in 1975. Most of this activity was confined to the area immediately east of Lone Ridge, northwest of Tyonek.

Spruce beetle activity remained at low levels on most of the Kenai Peninsula. Increased mortality was detected on about 7,900 acres of white spruce in the Resurrection Creek drainage of the Chugach National Forest. Thirty ground plots had infestation rates ranging up to 67 percent. Data from 15 of the plots in the most heavily infested area revealed an average infestation rate of 22 percent. The increase in spruce beetle populations was probably due to the extensive windthrow which occurred throughout the Resurrection Creek drainage in 1974 and 1975.

Eastern larch beetle, *Dendroctonus simplex* LeC. The area of scattered tamarack mortality remain at approximately 350,000 acres as in 1975. Although the area of infestation remained roughly the same, increased activity occurred in the northeastern portion of the infestation. Nearly 50 percent of the tamarack along creek drainages in this area had been killed. The affected area was bounded by Minchumina and Chilchukabena Lakes on the north and Mount McKinley National Park on the south. It extended from the Foreaker River on the west across the McKinley River to Moose Creek on the east.

Cedar bark beetle, *Phloesinus* sp. The presence of cedar bark beetle continued to be associated with Alaska-yellowcedar and western redcedar mortality on Kupreanof and Mitkof Islands in southeast Alaska. Bark beetle activity was primarily confined to scrub cedar stands on poorly drained sites. Mortality in these stands normally occurs in small pockets of several trees each.

Spear-marked black moth, *Rheumaptera hastata* (L.). Spear-marked black moth populations infesting nearly 2.7 million acres in interior Alaska collapsed. Only scattered light defoliation in a few areas in the vicinity of Fairbanks was detected. Spear-marked black moth populations in the Talkeetna area also collapsed with no visible defoliation being discovered during detection flights.

A larch defoliator, *Zeiraphera*, new species. A new budmoth species, similar to *Zeiraphera improbana* (Wlk.), defoliated 590,000 acres of tamarack in the Tanana River Valley. This was a 60-percent increase over the area defoliated in the spring of 1975. Probably no tree mortality will occur because defoliation occurs in the spring and tamarack refoliates soon after.

Leaf rollers, *Epinotia* sp. and *Archips* sp. Residents near Anchorage, Eagle River, Plamer, and portions of the northern Kenai Peninsula witnessed extreme cases of leaf-rolling on paper birch. A total 14,100 acres were affected. Leaf-rolling was so severe (in some cases 100 percent of the leaves) that from a distance the trees appeared completely defoliated. Leaf rollers on ornamental paper birch are a recurrent problem in south-central Alaska. The intensity of activity, however, seemed to be much heavier in 1976.

Western blackheaded budworm, *Acleris gloverana* (Wlshm.). Budworm populations decreased markedly from the already low levels of 1975. No defoliation was detected during aerial surveys of most of southeast Alaska. Budworm larvae were found at 18 of 95 plots sampled. The general population decline was partly attributed to cool summer temperatures.

Hemlock sawfly, *Neodiprion tsugae* (Midd.). The hemlock sawfly population decreased to insignificant levels. Sawfly larvae were found at 10 of the 95 permanent plots sampled. The number of sawfly larvae on a standard three-tree sample ranged from 1 to 14 larvae.

As in 1974 and 1975, no defoliation attributable to the hemlock sawfly was detected on aerial surveys which covered much of the Tongass National Forest.

Status of Diseases

Hemlock dwarf mistletoe. *Arceuthobium tsugense* (Rosend) G. N. Jones. The Stikine Area of the Tongass National Forest was the center of dwarf mistletoe control activity in southeast Alaska. Infected residual trees were removed from 4,474 acres of recently logged stands.

Siroccous shoot blight, *Sirococcus strobilinus* (Pruess.) The range of sirococcus in Alaska extended northward to Yakutat where it was found on hemlock reproduction. Thomas Bay, near Petersburg, continued to be the center of sirococcus activity. Field work for an evaluation to provide a quantitative estimate of the impact of sirococcus infection on the photosynthetic capability and subsequent growth potential of infected hemlock was completed in early September.

Spruce needle rust, *Chrysomyxa ledicola* (Pk.) Lagerh. The incidence of needle rust on Sitka spruce

was low in southeast Alaska in 1976, with the exception of the Mendenhall Valley near Juneau.

Alaska-yellowcedar mortality. Cause(s) unknown. Alaska-yellowcedar continued to die at an abnormal rate throughout the northern half of southeast Alaska. Symptoms resembling those caused by *Phytophthora* spp. were found on the roots and stems of dying Alaska-yellowcedar near Petersburg.

Other diseases. Spruce needle and twig necrosis. White spruce in the Anchorage and Kenai Peninsula areas had considerable twig and needle necrosis throughout their crowns. No pathogens were associated with the necrosis; it was probably a moisture problem related to an unusually dry spring and summer.

Birch and aspen injury. An examination of forest inventory plots, established 6 years ago in south-central and interior Alaska, revealed considerable birch and aspen damage caused during plot establishment. Birch on the survey plots had bleeding cankers where increment cores were taken. Aspen reacted to the use of the increment hammer by developing longitudinal areas of cambial necrosis. Aspen also reacted adversely to the aluminum nails used to mark the dbh point. Swellings developed around the nails in some instances and longitudinal areas of cambial necrosis developed in others.

Decay estimation in Sitka spruce and western hemlock. Results of an R-10 and PNW cooperative study on decay estimation were published in 1976 as USDA Forest Service Research Paper, PNW-204. This paper by Wilbur A. Farr, Vernon J. Labau, and Thomas H. Laurent gives prediction equations and guidelines for estimating decay in old-growth Sitka spruce and western hemlock in southeast Alaska. In the study, decay percentages in hemlock and spruce were significantly related to position of external indicators, tree age, and tree diameter. Decay percentages in hemlock were also related to latitude.

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